МИНИСТЕРСТВО НА ЗЕМЕДЕЛИЕТО, ХРАНИТЕ И ГОРИТЕ

ПРОГРАМА ЗА МОРСКО ДЕЛО И РИБАРСТВО

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The survey was carried out during the period November - December 2018 in Bulgarian Black Sea area on board of R/V HAITHABU" in execution of National Programs of Bulgaria for data collection in 2018.

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1. Results from pelagic survey in June 2019

1.1. Summary

Pelagic Trawl Survey was accomplished in June 2019 in the Bulgarian Black Sea area. Scientific team has produced a biological analysis of the results obtained in the marine area.

The survey of pelagic trawl was carried out in June 2019 in the Bulgarian Black Sea area. Biological analysis is based on the biomass of the species found during the study. In addition, an analysis of the distribution and abstraction of the other species caught as by-catch is presented. The Black Sea Sprat (Sprattus sprattus) is a key species for the Black Sea ecosystem. Together with the anchovy, sprat is one of the most abundant, planktivorous, pelagic species. The level of its stocks depends on the conditions of the environment mainly and on the fishing effort.

The changes in the environment due to anthropogenic influence, affect the dry land as well as the world ocean. The level of the sea pollution and its “self-purifying” ability are completely different. There is a clear indication of changes in the nature equilibrium in the corresponding ecological niches.

The greatest impact in the world ocean has the commercial fishery, which directly devastates a significant part of the given species populations. As a result of this some of the species stocks are declined or depleted.

As a result of the excessive exploitation, altered habitats and climatic variations numerous of the commercial species are critically endangered or vulnerable.

The abundance of the given fish species generations is dependent on different abiotic and biotic factors. With great importance are: the level of fishing mortality, changes in trophic levels due to mass occurrence of the ctenophore Mnemiopsis leidyi, algal blooms which lead to hypoxia in the shallower waters with mass mortality

of the bottom dwelling organisms and etc.

Recent state of the sprat stock biomass (aggregations) off Bulgarian Black sea coast show relative stability i.e. taking into consideration almost constant level of exploitation (in western and north-western part of the Black Sea) in the last years the stock possibly is underexploited yet. Estimates of the numbers and size distributions of fish stocks based on experimental trawling have become a necessity in fisheries management (GodØ, 1990). The main assumption in these studies is that the level of catches are constant, no matter how long the trawling is. Any deviation from the linear dependence between the catch and the magnitude of the effort applied to the fishery can have a significant impact on the composition of the catches and the estimates of the numbers and to deviate from the results of the trawl studies (Wassenberg et al., 1998). The duration of the fishing effort during the trawling period may last up to 200 min (GodØ, 1990), but for economic reasons, together with the need for multiple reps and maintaining statistical validity, the duration of trawling is reduced. Thus, the standard trawl duration varies from 30 to 120 minutes for each selected station. Some authors (Godø, 1990; Wassenberg et al., 1998; Somerton et al., 2002) allow larger specimens to swim in the trawl without entering the bag and that trawls of varying lengths may affect the levels the catches and the size distribution of the trawl. In this way, some size groups may not be captured in short-haul trawls.The average catch (in units of weight or in units) per unit of effort or per unit area is the inventory of the stock (assumed to be proportional to the stock). This index can be converted into an absolute measure for biomass by the so-called Area Method ". The "area method" is the so-called holistic methods (www.fao.org).

All analyses are based on the biomass and density estimates and by geographical strata. All the teams calculated their standard statistical estimates using the same software.

This report presents successively the results obtained at these two levels. The regional reports are presented in an order following the coast, from the northern to

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southern part of the Black Sea. The document is completed by a series of tables and figures related to the biomass/abundance indices and length frequency distributions of the species included in the reference list.

2. R/V vessel and gears

The Pelagic Trawl survey (PT) was accomplished on board of research vessel "HaitHabu",. The main characteristics of the ship are given bellow:

Picture 2.1. R/V HaitHabu

R/V HaitHabu

- IMO: 8862686
- MMSI: 207139000
- Позивна: LZHC
- Flag: Bulgaria [BG]
- AIS Vessel Type: Other
- Gross Tonnage: 142
- Length Overall x Breadth Extreme:24.53m × 8m Crew: 6
-

Picture 2.2. Catch of the OTM

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3. Material and Methods

Pelagic Trawl survey was accomplished with accordance with National Programs for Data Collection in Fisheries sector of Bulgaria for 2019. The study held during the period of June 2019, in the area enclosed between Durankulak and Ahtopol (Bulgaria) with total length of coastline of 370 km. Study area encloses waters between 42°05' and 43°45' N and 27°55 and 29°55 E.

During the survey, total 37mid-water hauls were carried out in Bulgarian area (June 2019). The survey undergoes during the day and the following types of data were collected:

- Coordinates and duration of each trawl
- Sprat total catch weight
- Separation of the by-catch by species
- Composition of by-catch
- Conservation of the samples

3.1 Sampling design

Picture 3. Trawling operation

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To establish the abundance of the reference species (*Sprattus sprattus*) in front of the Bulgarian coast a standard methodology for stratified sampling was employed (Gulland, 1966;). To address the research objectives the region was divided in 3r strata according to depth – Stratum 1 (15 - 30 m) Stratum 2 (35 – 50 m), Stratum 3 (50 – 100m)

The study area in Bulgarian waters was partitioned into 128 equal in size not overlying fields, situated at depth between 16 - 92 m. At 37of the fields chosen at random, sampling by means of mid-water trawling was carried out.

Each field is a rectangle with sides 5' Lat × 5' Long and area around 62.58 km^{-2} (measured by application of GIS), large enough for a standard lug extent in meridian direction to fit within the field boundaries. The fields are grouped in larger sectors – so called strata, which geographic and depth boundaries are selected according to the density distribution of the species under study. At each of the fields only one haul with duration between 30 - 40 min. at speed 2.7-2.9 knots was carried out.

As a result of the trawling survey a biomass index was calculated.

3.2 Onboard sample/processing

The data recorded and samples collected at each haul include:

- Depth, measured by the vessel's echo sounder;
- GPS coordinates of start/end haul points;
- Haul duration;
- Abundance of sprat caught;
- Weight of total sprat catch;
- Abundance and weight of other large species;
- Species composition of by-catch;
- 4% Formaldehyde solution with marine water was used for conservation of sprat for stomach content examination.

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3.3 Laboratory analyses

The samples collected onboard were processed in the laboratory for determination of age and food composition.

The age was established in otoliths under binocular microscope.

The food spectrum was determined by separation of the stomach contents into taxonomic groups identified to the lowest possible level.

3.4 Statistical analyses

Swept area method

This method is based on bottom trawling across the seafloor (area swept), weighted with chains, rock-hopper and roller gear, or steel beams. Widely used direct method for demercal species stock assessment.

The main point of the method: the trawl doors are designed to drag along the seafloor for defined distance. Trawling area was calculated as follows:

(1) $$a = D * hr * X2$$
$$D = V * t$$

(Where: a – trawling area, V – trawling velocity, hr* X2 – trawl door distance, t – trawling

duration (h), D – dragged distance on the seafloor;

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(2) $D = 60 * \sqrt{(Lat_1 - Lat_2)^2 + (Lon_2 - Lon_1) * \cos(0.5 * (Lat_1 + Lat_2))}$

(3) $D = \sqrt{VS^2 + CS^2 + 2 * VS * CS * \cos(dirV - dirC)}$,

Where, VS is vessel velocity, CS - present velocity (knots), dir*V* vessel course (degrees) and *dirC*- present course (degrees).

Stock biomass is calculated using catch per unit area, as fraction of catch per unit effort from dragged area:

(4) $(\frac{C_{w/t}}{a/t}) = C_{w/a} kg / sq.km$

Where: *Cw/t* – catch per unit effort, a/t – trawling area (km2) per unit time;

Stock biomass of the given species per each stratum could be calculated as follows:

(5) $B = (\overline{C_{w/a}}) * A$

Where: $\overline{C_{w/a}}$ - mean CPUA for total trawling number in each stratum, A- area of the stratum.

The variance of biomass estimate for each stratum is (equation 4):

(6) $VAR(B) = A^2 * \frac{1}{n} * \frac{1}{n-1} * \sum_{i=1}^{n} \left[Ca(i) - \overline{Ca} \right]^2$

Total area of the investigated region is equal to the sum of areas of each stratum:

A = A1+A2+A3

Average weightened catch per whole aquatic territory is calculated as follows:

(7) $\overline{Ca}(A) = Ca1 * A1 + Ca2 * A2 + Ca3 * A3 / A$

Where: Ca1- catch per unit area in stratum 1, A1 – area of stratum 1, etc., A- size of total area.

Accordingly, total stock biomass for the whole marine area to:

(8) $B = \overline{Ca}(A) * A$

Where: $\overline{Ca}(A)$ - average weightened catch per whole investigated marine area, A –

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total investigated marine area.

Estimation of Maximum Sustainable Yield (MSY)

The Gulland's formula for virgin stocks is used – equation 7:

(9) MSY = 0.5*M*Bv

where: M – coefficient of natural mortality; Bv – virgin stock biomass.

Relative yield-per-recruit model with uncertainties

(10) $$Y'/R = E * U^{M/k} \left\{ 1 - \frac{3U}{(1+m)} + \frac{3U^2}{(1+2m)} - \frac{U^3}{(1+3m)} \right\}$$

where: U = 1-(Lc/L∞)

m = (1-E)/(M/k) = k/Z

E = F/Z – exploitation coefficient.

Lenght-converted catch curve

A number of methods are available with the help of which total mortality (Z) can be estimated from length-frequency data. Thus it is possible to obtain reasonable estimates of Z from the mean length in a representative sample, or from the slope of Jones' cumulative plot. In this article, a variety of approaches for analysing length-frequency data are presented which represent the functional equivalent of [age structured] catch curves; these "length-converted catch curves" are built around assumptions similar to those involved in age-structured catch curves.

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3.5. Age estimation

6 cm (0+)

7.5 cm (1+)

8.2 cm (1+)

9 cm (2+)

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9.5 (3+)

10.7 (4+)

As it is well known, the Calcified Structures (CS) are usually used to assign age useful to obtain their growth model and so, to reconstruct age composition of exploited fish populations. Fish ageing implies the presences in the CS of a structural pattern, in terms of succession of opaque and translucent zones and the knowledge of the periodicity of this deposition pattern. Calcified structures available for fish ageing are different: otoliths (sagittae, lapilli, asterischi), scales, vertebrae, spines and opercular bones (Panfili et al., 2002). For the selected stocks the CS utilized is the sagittae. The most important aspects (difficulties, extraction, storage, preparation method, ageing criteria) regarding the age analysis are addressed by species. Otoliths are important for fish and fisheries scientists. Otoliths are playing role balance, motion and sound. These structures are effective from growth to death in entire life cycle. They are most commonly used for age in order to determine growth and mortality research. Research on otoliths began in 1970s and continues to 21st century. Periodic growth increments which in scales, vertebrae, fin rays, in cleithra, opercula and otolith are used to determine annual age in many fish species.

Researchers have used otolith reference collections and photographs in publications to aid in identifications. Otoliths have a distinctive shape which is highly specific, but varies widely among species.

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Biologists, taxonomists and archaeologists, based on the shape and size of otoliths determined fish predators feeding habits (Kasapoglu and Duzgunes, 2014). In teleost fishes, otoliths are the main CS for the age determination and it is widely used in fisheries biology. On the other hand analysing O2 isotopes in their structure is useful to determine fish migrations between fresh water and sea as well as species and stock identification. Otoliths are the balance and hearing organs for the fish. They are in three types located on the left and right side of the head in the semi rings; "sagitta" in the saccular, "lapillus" in the lagenar and "asteriskus" in the utricular channels. Place, size and shape of these three types are different by species, the biggest one is sagitta and the smallest one is asteriscus. So, sagitta is the one mostly used in age determination in bony fishes (Aydın, 2006). Other reasons for the preference to otoliths are;

-Their formation in the embryonic phase which shows all the changes in the life cycle of the fish,

- Existence in the fish which have no scales,

- Giving better results than the scales and more successful age readings in older fish

than their scales,

- No resorption or regeneration,

- Having same structure in all the individuals in the same species (Jearld, 1983).

On the other hand, their disadvantages are the obligation of dissecting the fish and some failures in age determination due to crystal like formations by irregular CaCO3 accumulations on the otoliths.

3.5.1 Otolith Preperation for sprat

Sampling of the fish for otolith extraction from the overall samples is very important

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to have representative samples for the catch. Number of otoliths needed is lower for the species having smaller size range than the species having larger size range. According to the availability 5 fish for each length group may be better for age readings to be representative for the population. Each of the individuals should be recorded individually with place of catch, date and ID number. These steps are useful for the process:

- For each fish total length (±0,1 cm), total weight (±0,01g), sex, maturation stage (I-V), gonad weight (±0,01g) are recorded.
- Sagittal otoliths of each fish are removed by cutting the head over eyes after all individual measurements. Then, rinsed and immersed in 96% ethyl alcohol to get rid of organic wastes/residuals and finally kept in small chambers in plastic roomed boxes with the sample number and other operational information.

3.5.2 Preperation of the otoliths for the age determination

Otoliths are put into small black convex glasses containing 96% ethyl alcohol for age readings under binocular stereo microscope which is illuminated from top and sides (Fig 3.5.2.) (Polat ve Beamish, 1992). Magnifying level depends on the size of the otolith; X4 is good for sprat and X1 for turbot.

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Figure 3.5.2. Binoculer stereo microscobe with top and side illumination

3.5.3. Age readings and commenting on annuluses

In order to prevent bias, during age reading reader should not refer length and weight of that fish. But information on the date of the catch and gonadal state is very important. First step is to clarify the place of the center and the first age ring. After that, observation of the successive rings, whether they are continuous or not is important.

Finally, determination of the fish in growth or just at the end of the growth period by checking characteristics of the ring at the edge of the otolith to decide it is opaque or hyaline. After these procedures otoliths can be read under these protocols which are very important to provide data on age to determine realistic population parameters

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and reduce uncommon procedures and biases by standardized age reading criteria.

3.5.4. Sprat (Sprattus sprattus)

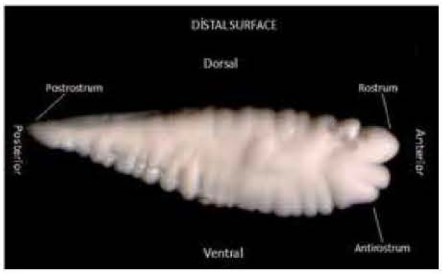
In sprat left and right otoliths shows isometric growth. These are small and transparent (Fig 3.5.4). Age readings can be done over otolith surface by clear ring views. Due to summer and winter growths there are two different nucleus formation in the center; spring recruits has opaque, late fall recruits has hyaline rings which is taken into consideration during age readings (Pısıl, 2006).

a

b

TL: *a* – 6.2 cm; *b* – 6.7 cm

S.sprattus

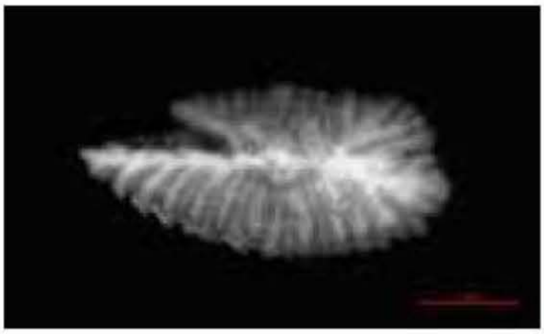


Merlangius merlangus

Trachurus mediterraneus

E.encrasicolus

M.barbatus



P.salstarix

Figure 3.5.4. Sprat, anchovy, horse mackerel, red mullet, bluefish otoliths

3.5.5. Age reading protocol

1. Dissected otoliths rinsed and threated with 96 % ethyl alcohol and stored dry.
2. Readings are carried out by inspecting the whole otolith in 96% ethyl alcohol in black colored convex glass bowl under reflected light against a dark background.
3. Magnification set considering the biggest otolith size which is totally fit the visual capacity of the lens. It is aimed not to change magnification rate which may enable false rings visible in bigger otoliths and permits to see true rings (hiyalins) better by unchanging the color contrasts. Thats why magnifation rate X4 is selected for the sprat otoliths.
4. Otolith samples observed from distal surface as a whole, broken ones are not used.
5. Birthday of the sprat accepted as 1st of January as the common principle for the fish living in the Northern semiphere in line with the sub-tropic fish growth models.
6. Central point surrounded by the hyalin rings which is one in some cases or two for the others, is formed after the end of consumption of yolc sac and starting of the free feeding, and known as “stock rings”. Next opaque accumulation is known as “first year growth ring”. This ring keeps its circular form in the postrostrum region. Together with this ring and the next hyalin ring forming “V” shape in the rostrum, is accepted as first age rings.
7. Tiny and continious consantric rings prolonge close to real hyalin ringed are counted togetherwith the real one as one age. This ring may be either a very tiny and opaque inside the hyaline band or tiny hyaline ring near the outer edge of the opaque ring.
8. Sprat and some other short lived species has very fast growth rate especially in

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the first two years. Width of the growth bands after 2nd year ring has relatively getting narrower. This issue should be kept in mind in the older age ring readings.

Number of tiny and weak hyaline rings, known as false rings, in the opaque region, is not so high and, their seperation from age rings is rather easy. When they are so much and unseperable, these otoliths should not be used.

Photo Lenght measurements on board

3.6. Sex and Maturity Estimation

3.6.1 SPRAT

The European sprat (*Sprattus sprattus* L.) is a small short-lived pelagic species from the family Clupeidae. Sprat has a wide distribution including shelf areas of the Northeast Atlantic, the Mediterranean Sea and the Baltic Sea. Sprat is most abundant in relatively shallow waters and tolerates a wide range of salinities. Spawning is pelagic in coastal or offshore waters and occurs over a prolonged period of time that may range from early spring to the late autumn. Sprat is an important forage fish in the North Sea and Baltic Sea ecosystems. Commercial catches from pelagic fisheries are mainly used for fish meal and fish oil production. Three subspecies of sprat have been defined i.e. *Sprattus sprattus sprattus* L., distributed along the coasts of Norway, the North Sea, Irish Sea, Bay of Biscay, the western coast of the Iberian peninsula down to Morocco, *Sprattus sprattus phalericus*, R) in the northern parts of the Mediterranean and the Black Sea, and *Sprattus sprattus balticus* S. in the Baltic Sea. Knowledge about stock structure, migration of sprat and mixing of populations among areas is limited. Questions have been raised about the geographic distribution and separation of stocks and their interaction with neighboring stocks (ICES 2011). The apparent overlap e.g. between North Sea sprat and English Channel sprat seems very strong, whereas the overlap between North Sea sprat and Kattegat sprat is not as strong and varies between years. A distribution wide phylo-geographic study showed that sprat in the Western Mediterranean is a subgroup of the Atlantic group and that these two populations are closer to each other than to sprat in the Eastern Mediterranean and Black Sea (Debes et al., 2008).

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3.6.2. Maturity Stages of Sprat

It is very important to use standardized maturity scales for sprat (and all species) to evaluate sampling strategies and timing for accurate classification of maturity in order to provide reliable maturity determination for both sexes. For sprat, small gonad size and the batch spawnings by several cohorts of eggs over a long period of time are the main challenges for standardizing a maturity scale.

According to the ICES (2011), present standardized maturity scales of sprat include 6-stages for both sexes (Fig. 3.6.2.Table 3.6.2.)

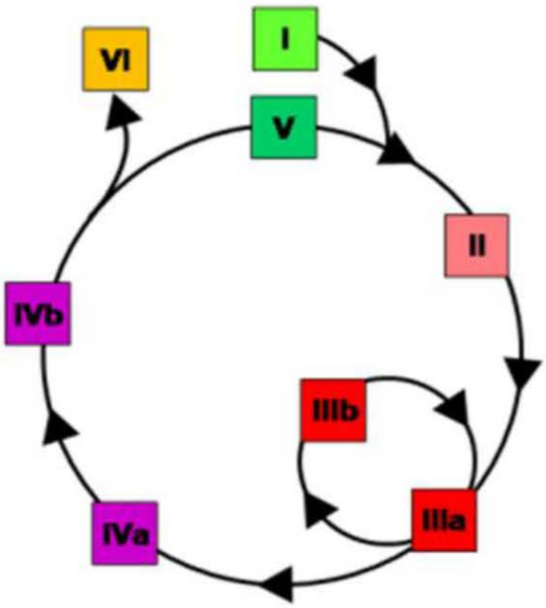

Figure 3.6.2. Scale with six maturity stages in sprat (Name of the stages are given in Table 3.6.3)

In particular, specimens without visible development have been combined into Immature and Preparation, whereas the spawning stage has been sub-divided into a non-active spawning stage (maturing and re-maturing characterized by visible development of gametes) and an active spawning stage indicated by hydrated eggs/running milt. The integration of maturing and re-maturing into the spawning

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stage allows an accurate determination of maturing and spawning specimens and reliable assessment of the spawning fraction of the population.

Table 3.6.3. Macroscopic and histological characteristics of gonadal development stages

Stages	*Macroscopic Characteristics*	*Histological characteristics*
FEMALES (OG: Oogonia, PG1: Early previtellogenic oocytes, PG2: Late previtellogenic oocytes, CA: Cortil alveoli oocytes, VT1: Early vitellogenic oocytes, VT2: Mid vitellogenic oocytes, VT3: Late vitellogenic oocytes, HYD: Hydrated oocytes, POF: Postovulatory follicles, SSB: Spawning stock biomass).		
I-Immature	*Juvenile: ovaries threadlike and small; transparent to wine red and translucent in color; sex difficult to determine; distinguishable from testes by a more tubular shape; oocytes not visible to the naked eye*	*OG+/-PGI*
II-Preparation	*Transition from immature to early maturing; oocytes not visible to the naked eye; ovaries yellow-orange to bright red in color; ovaries occupy up to half of the abdominal cavity. This stage is not included in SSB.*	*PG1, PG2, CA*

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III. Spawning		
a. Spawning(inactive)	*Maturing and re-maturing: yolked opaque oocytes visible to the naked eye; ovaries change from semi-transparent to opaque yellow-orange or reddish in color as more oocytes enter the yolk stage; ovaries occupy at least half of the body cavity; re-maturing ovaries may be red to grey-red or purple in color and less firm than an ovary maturing first batch, few hydrated oocytes may be left*	*PG1, PG2, CA, VT1, VT2, VT3, +/- POF*
b. Spawning (active)	*Spawning active. Hydrated eggs are visible among yolked opaque oocytes; hydrates oocytes may be running; ovaries fill the body cavity; overall color varies from yellowish to reddish.*	*PG1, PG2, CA, VT1,VT2, VT3, HYD, POF*
IV.a Cessation	*Baggy appearance; bloodshot; grey-red translucent in color; atretic oocytes appear as opaque irregular grains; few residual eggs may remain*	PG1, PG2, POF, atretic oocytes, residual HYD
IV.b. Recovery	*Ovaries appear firmer and membranes thicker than in sub-stage IV.a; these characteristics together with the slightly larger size distinguish this stage from the virgin stage; ovaries appear empty and there are no residual eggs; transparent to wine red translucent in color*	PG1, PG2, atretic VT oocytes

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V. Resting	*Ovaries appear more tubular and firmer; oocytes not visible to the naked eye; transparent or grey-white to wine red in color with well-developed blood supply; this stage leads to stage II.*	PG1, PG2 +/- atretic oocytes
VI. Abnormal	*a) infection; b) intersex - both female and male tissues can be recognized; c) one lobe degenerated; d) stone roe (filled with connective tissue); e) other*	Abnormal tissue
MALES (SG: Spermatogonia; PS: Primary spermatocytes; SS: Secondary spermatocytes; ST: Spermatids; SZ: Spermatozoa; SSB: Spawning stock biomass)		
I. Immature	*Juvenile: Testes threadlike and small; white-grey to grey brown in color; difficult to determine sex, but distinguishable from ovaries by a more lanceolate shape (knife shaped edge of distal part of the lobe).*	SG, PS
II-Preparation	*Transition from immature to maturing: Testes easily distinguishable from ovaries by lanceolate shape; sperm development not clearly visible; reddish grey to creamy translucent in color; testes occupy up to ½ of the abdominal cavity; this stage is not included in SSB.*	SG, PS, SS, potentially few ST

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III. Spawning a. Spawning(inactive)	*Maturing and re-maturing: Testes occupy at least half of the body cavity and grow to almost the length of the body cavity; the empty sperm duct may be visible; color varies from reddish light grey, creamy to white; edges may still be translucent at the beginning of the stage, otherwise opaque; re-maturing testes may be irregularly colored with reddish or brownish blotches and grey at the lower edge with partly whitish remains of sperm*	*SG, PS, SS, ST, SZ*
c. Spawning (active)	*Spawning active: testes fill the body cavity; Sperm duct filled and distended throughout the entire length; sperm runs freely or will run from the sperm duct, if transected; color varies from light grey to white..*	*SG, PS, SS, ST, SZ*

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IV.a Cessation IV.b. Recovery	*Baggy appearance (like an empty bag when cut open); bloodshot; grey to reddish brown translucent in color; residual sperm may be visible in sperm duct.* *Testes appear firmer and the testes membrane appear thicker than in stage IVa due to contraction of the testes membrane; these characteristics together with the slightly larger size distinguish this stage from the virgin stage; testes appear empty and no residual sperm is visible in the sperm duct; reddish grey to greyish translucent in color.*	*SG, PS, atretic SS, ST and SZ* *SG, PS, potentially SS, atretic SZ*
V. Resting	*Testes appear firmer, development of a new line of germ cells; grey in color; this stage leads to stage II.*	*SG, PS, SS*
VI. Abnormal	*a) infection; b) intersex - both female and male tissues can be recognized; c) one lobe degenerated; d) other.*	*e.g. oocytes visible among spermatogeni c tissues*

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3.6.3. Batch fecundity

All fish were measured to the nearest 1 mm in the Total Length (TL) and weighted to the nearest 1 g. Gonads of the fish were examined under a dissecting microscope for its external features such as turgidity and colour in order to determine a maturity stage. The sex ratio also calculated in this study (i.e., No. of males/No. of females (Simon et al., 2012). The female was determined by the macroscopic observation of matured ovary (Laevastu, 1965a).

Batch fecundity can vary considerably during the short spawning season, low at the beginning, peaking during high spawning season and declining again towards the end.

Annual egg production is the product of the number of batches spawned per year and the average number of eggs spawned per batch.

Batch fee undi t Y. 0 f s prat was '. determined as'Hydrated Oocyte Method'. (HUNTER et ale 1985). Oilly hydrated females.were used. After sampling their body cavity was opened and they were 'preserved in a buffered formalin solution

(HUNTER 1985). The ovary free female weight ind the ovary''weight were determined: Three tissue samples of - 50 mg were removed from different parts of the ovary and their exact were determined. Under binocuklar number of hydrated oocytes, in each of the three subsamples was determined.

Hydrated oocytes can easily be separated from all other types of oocytes because of their large size t their translucent appearance and their wrinkled surface which is due to formalin preservation. Batch fecundity 'was estimated 'based, on· the average number of hydrated oocytes per unit weight of the three subsamples.

Gonadosomatic Index (GSI) was determined monthly. GSI was calculated as:

$$GSI = \frac{GW}{SW} X\ 100$$

where, GW is gonads weight and SW is somatic weight (represents the BW without GW)

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For the estimation of sprat growth rate, the von Bertalanffy growth function (1938) is used, (according to Sparre, Venema, 1998):

(11) $L_t = L_\infty \left\{1 - \exp\left[-k(t - t_0)\right]\right\}$

(12) $W_t = W_\infty \left\{1 - \exp\left[-k(t - t_0)\right]\right\}^n$

where: Lt, Wt are the length or weight of the fish at age t years; L∞, W∞ - asymptotic length or weight, k – curvature parameter, to - the initial condition parameter.

The length – weight relationship is obtained by the following equation:

(13) $W_t = qL_t^{\ n}$

where: q – condition factor, constant in length-weight relationship; n – constant in length-weight relationship.

Coefficient of natural mortality (M)

Pauly's empirical formula (1979, 1980) is applied:

(14) $\log M = -0.0066 - 0.279 * \log L_\infty + 0.6543 * \log k + 0.4634 * \log T^\circ C$

(15) $\log M = -0{\cdot}2107 - 0{\cdot}0824 \log W_\infty + 0{\cdot}6757 \log K + 0{\cdot}4627 \log T°C$

where: L∞, W∞ and к – parameters in von Bertalanffy growth function; T°C - average annual temperature of water, ambient of the investigated species.

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3.7. Feeding of sprat (*Sprattus sprattus*, L) in VI.2019

Material and method

The study includes analysis of stomach content composition of 110 sprat specimens, collected in front of the Bulgarian Black Sea coast during 08.VI - 20.VI.2019, and it encompasses additional analyses of the zooplankton species composition and biomass in the marine environment.

The coordinates and information about the sampling sites were presented in Table 3.7.1.

Table 3.7.1. Investigated area in 08.VI - 20.VI.2019

Date	№	Coordinates	Depth (m)	Zooplankton stations	Sprat food
08.06.2019	1	42.46; 27.83	37	1	Sp1
08.06.2019	2	42.34; 27.92	39	2	Sp2
08.06.2019	5	42.25; 28.11	60	3	Sp3
09.06.2019	7	42.39; 27.81	42	4	Sp4
09.06.2019	9	42.25; 27.90	41	5	Sp5
11.06.2019	13	42.47; 27.81	36	6	Sp6
12.06.2019	18	42.62; 27.84	27	7	Sp7
12.06.2019	22	42.65; 27.79	31	8	Sp8
18.06.2019	27	43.36; 28.43	16	9	Sp9
19.06.2019	35	43.21; 28.09	21	10	Sp10
20.06.2019	37	43.03; 27.97	22	11	Sp11

Per trawl catch, about 10 fish specimens were separated and preserved in 10 % formaldehyde: seawater solution. The absolute length (TL, to the nearest 0.1 cm) and weight (to the nearest 0.01 g) of fish specimens were measured. Under laboratory conditions, the stomachs of the selected animals were weighted with

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analytical balance (to the nearest 0.0001 g). The food mass of each individual has been calculated as a difference between the weights of full and empty sprat stomach.

The stomach content was investigated under a microscope for the estimation of species composition and prey number. The prey biomass was estimated by multiplication of the number of consumed mesozooplankton species by their weights.

The following indices were calculated:

1. Stomach fullness index (ISF) as a per cent of body mass: (stomach content mass/fish mass) *100; and

2. Index of relative importance - IRI, Pinkas et al. (1971): IRI = (N+M) x FO; where N - the proportion of prey taxa (species) in the diet by numbers (abundance); M - the percentage of prey taxa (species) in the diet by mass; FO - frequency of occurrence among fish.

The zooplankton samples in the marine environment were gathered from the whole water layer (bottom- surface) with a plankton set (opening diameter d = 36 cm; mesh size 150 μm). The samples were fixed onboard ships with 4% formaldehyde: seawater solution (Korshenko & Aleksandrov, 2013). The mesozooplankton species composition has been identified by “Guides for the Black and Azov Seas” (Morduhai-Boltovskii et al., 1968), and its quantity - by the method of Bogorov (Korshenko & Aleksandrov, 2013).

3.8. Selectivity of the fishing gear

The change in mesh size of the codend is the basis of the analysis of the selectivity in the calculations. The mesh size (a, mm) of the trawl bag is shown in Fig. 3.8.1. The study of the variation in the trawl selectivity is based on calculations at the corresponding change in the size of the "eye" side.

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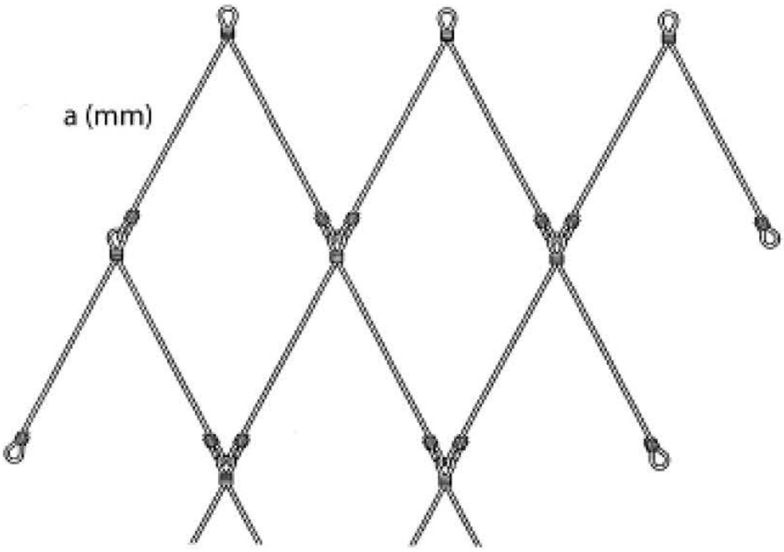

Figure 3.8.1. "Eye" of the codend and size a (mm)

Using the model of Tresthev (1974), it was worked out to construct an additional trawl bag to experimentally study the change in selectivity:

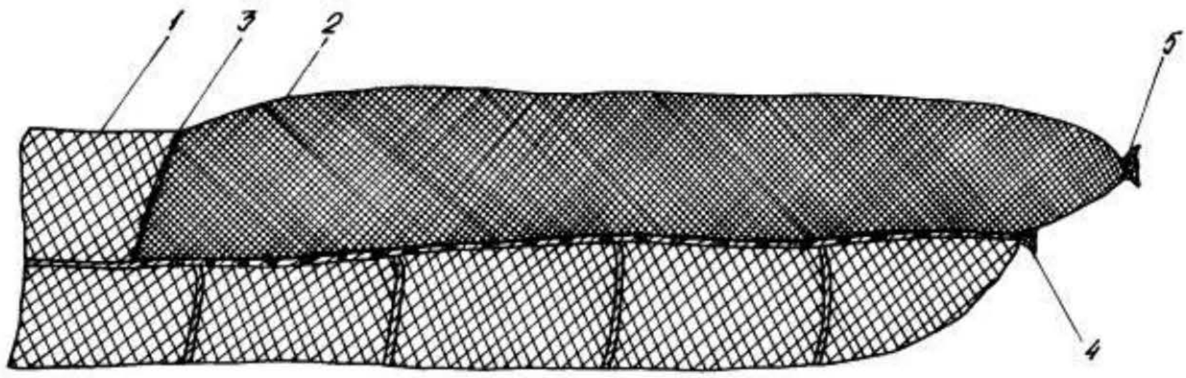

Figure 3.8.2. Codend bag scheme: 1 - main bag 2 - apron; 3 - connector, 4 - the main bag 5 - the trailer outer bag connection.

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Linear size measurements were used to evaluate the following biological parameters:

L50, L25 and L75 the amount at which 50%, 25% and 75% of the individuals entered into the fishing gear are detained therein;

Selectivity factor;

(c) an extent of selectivity

The dimensional selectivity of the trawl bag is determined by the relationship between

the probability p, the fish entering the bag and its size l (Holden, 1971). This link is described by the logistic function (Fryer, 1991):

$$p = \frac{e^{(v_1 + v_2])}}{(1 + e^{(v_1 + v_2])}}$$

Where v1 represents the intersection of the abscissa, v2 is the slope of the curve

following log-transformation. The L50, L25 and L75 function values can be estimated from the

following expressions:

$$L_{50\%} = \frac{v_1}{v_2} \qquad L_{25\%} = \frac{(-Ln(3) - v_1}{v_2} \qquad L_{75\%} = \frac{(Ln(3) - v_1}{v_2}$$

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$$SR = L_{75} - L_{25} \qquad SF = \frac{L_{50}}{meshsize}$$

Suppose that fish of size: l1, l2,. . .1N enter the trawl bag. Small fish may loose through the mesh (ie, have a low probability of retention), but as they grow in length, the chance to get rid of the net decreases. At some point, because of their increased size, they can not get out of the net (their probability of retention equals 1).

4. Results

4.1. Selectivity of the fishing gear

There are presented the possibilities of holding individuals from sprat of mesh size a = 8 mm; 7.5 mm and 6.5 mm (Table 4.1.) in order to trace the change in the probability of retention of individuals when changing the mesh size of the network.

Table 4.1. Possibilities for holding individuals from a twine in a "mid-water otter trawl" of different mesh sizes; Selectivity factor (SF) and Selectivity Spectrum (SR).

Размер на окото	селективност	8.00 mm	селективност	7.5 mm	селективност	6.5 mm
Вероятност за задържане	$L_{25\%}$	6.2 cm	$L_{25\%}$	5.4 cm	$L_{25\%}$	5.2 cm
	$L_{50\%}$	7.0 cm	$L_{50\%}$	6.2 cm	$L_{50\%}$	5.7 cm
	$L_{75\%}$	7.8 cm	$L_{75\%}$	7.0 cm	$L_{75\%}$	6.2 cm
	SF	4.4		4.13		4.77
	SR	1.6		1.6		1

In the trawl bag of mesh size a = 8.00 mm, the probability is that 25% of the specimens retained in the bag should have a size of 6.2 cm (L25 = 6.2 cm). With 50% probability (L50%), individuals with a size of 7.00 cm and the largest will be

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retained

probability of retention (L75%) were individuals with a linear size of 7.8 cm (Table 5.1.1, Fig.5.1).

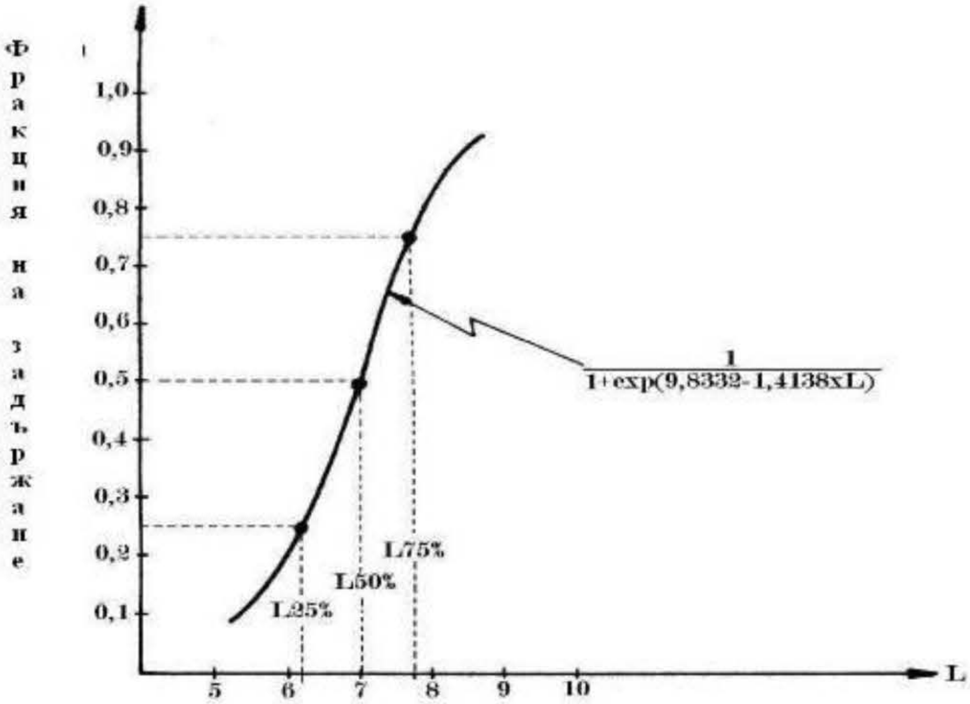

Figure 4.1. Graphical representation of L25%, L50%, L75% at the mesh size of the "bag" a = 8.00 mm.

The next scenario examined is to change the selectivity, with the mesh size being 0.5 mm smaller: 7.5 mm. In this case, 6.2 cm individuals will retain a probability of 50% in the trawl net (L50% = 6.2 cm, Table 5.1.1), which is 0.8 mm less than the case of mesh size a = 8mm. In this case, it reduces the size of the specimens that would be retained in the trawl with a probability of 25%, namely L25% = 5.4 cm. Reducing the network mesh from 8.00 to 7.5 cm results in a 75% retention probability of 7.00 cm specimens, which is 0.8mm less than the previous case. The selectivity factor for this particular case decreases to 4.13 and the SR selectivity

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range is maintained at the mesh size a = 8.00 cm. The proportion of the magnitude in both cases examined so far is the same, but with decreasing mesh size, the size of the retained specimens also diminishes. In the third case, the mesh size is a = 6.5 mm. Such a network will retain in a proportion of 50% individuals with TL = 5.7 cm, which is 1.3 cm less than in the case of mesh size of the net- a = 7mm.

In this case, the difference between the individuals of the trickles of certain dimensions retained in the bag (inner) with an eye of 6.5 mm in the proportion of 25, 50 and 75% will be 0.5 cm.

A codend of mesh size a = 6.5mm will hold fish in a proportion of 6.2 cm in a proportion of 75% and in a proportion of 25%, 5.2 cm in size, 5.1. The selectivity factor in this case increases to 4.77 (from 4.4 and 4.5) and the selectivity range is equal to one (SR = 1). It can be seen that in all cases with a mesh size of 6.5 mm, the change in the size of the detainees varies within a smaller range, but in all variants, the holdings are very much below the minimum allowable harvest size (2001) spatula, namely 7.00 cm. We should note the fact that active trawl-fishing gears are using nets with mesh sizes from 6.0 to 6.5 cm. This fact undoubtedly speaks of the fact that there are specimens that have not reached sexual maturity in different proportions. Not least, the fact that active fishing activity related to the use of trawls take place in the near coastal strip at a lower depth. It is well-known, from the biology of the species, which the large individuals, respectively the senior age groups, migrate to greater depths in search of favorable temperature and nutritional conditions. According to the calculations made on the selectivity of the trawl bag of different mesh size, it can be seen that at a = 8mm, 50% of the TL = 7cm individuals have a chance of being trapped while the TL = 7.8 cm 75% retention capability. A further reduction in mesh size leads to a reduction in the selectivity of the trawl. In eye mesh a = 7.0cm, L50% = 6.2cm and L75% = 7cm. For nets with a mesh size of 6.5mm, the size of the trait-retained individuals drops to 5.7cm at L50%. As the

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mesh of the bag grows, the number of small individuals that escape the trawl increases. At the same time, the average length of the fish caught, i.e. this is part of the breeding biomass that has already participated in the reproduction. The Regional Fisheries Commissions are aiming for maximum mesh sizes, which would allow maximum "extraction" of juvenile individuals.

The minimum allowable catch for sprat referred to in the Fisheries and Aquaculture Act (2001) is 7 cm. This fact is indicative that in order to comply with the measure of resource use referred to in the law, the mesh size of the trawl should be a = 8 mm, which would result in the proportion of individuals in the proportion of L75% = 7.8 cm . This measure is essential to protect the exploited resource from overloading and undermining stocks in the longer term.

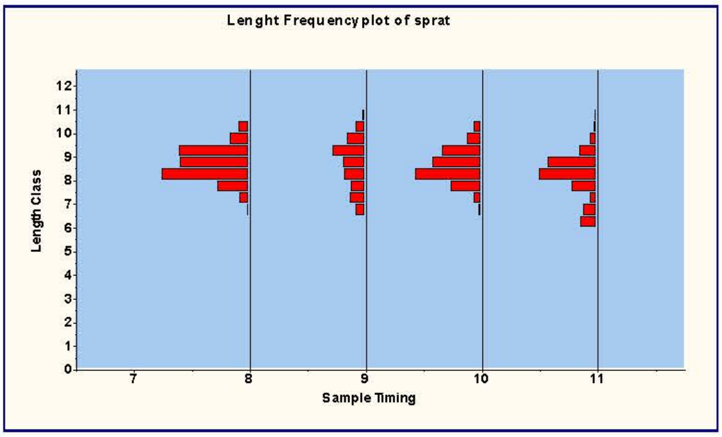

Figure 4.1.1. Linear dimensions of the sprat in the codend of the trawl

4.2. Abundance and biomass indices

Introduction

A total of 37 trawls in the Bulgarian marine area were carried out on board the R/v "HaitHabu". The total number of identified species is 24, of which 16 fish, 2 crustaceans, 2 molluscs and 4 macrozooplankton species. The most common species in total trawling operations (in terms of presence / absence) are (in descending order): in June 2019: S. sprattus (76.5%) M. barbatus (9.66%), and M. merlangius (4.86%) the other species such as A. immaculata, N melanostomus, G.niger, etc. have a negligible presence in catches in June 2019. Single specimens of A. stellatus, S. maximus, family Sparidae, Scorpaena porcus, Pegusa lascaris, etc. were caught years

In the Bulgarian Black Sea area 37 trawls were made in the period 08 - 20.06.2019. The trawling time is 30 and 40 minutes, between 16 m and 92 m deep, in the area between Kiten and Durankulak.

The studied area in Bulgarian waters was 8010.24 sq. Km. During the study period, the largest number belong sprat, which dominated the pelagic society.

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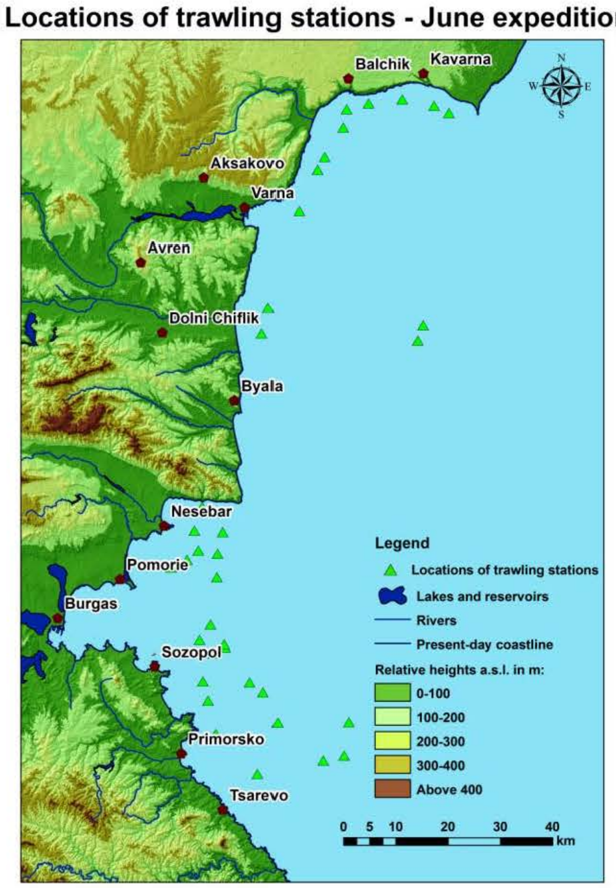

Figure 4.2.2. Location of trawl stations in the June 2019 survey

<u>Global Comments on Fish and Other Species:</u>

Sprat (*Sprattus sprattus*) The species had the highest recorded biomass and catch per unit area in the study areas in June 2019. At stratum 15-30m CPUA = 1867.7 kg.km^{-2} and 12 497 t. In depth plots 30-50m: 1731 kg.km^{-2} and biomass 7557 t., For stratum (united) 50-100m the clusters were CPUA = 1416 kg.km^{-2} and and 5850 t.

Red mullet *(Mullus barbatus)*

In June 2019, the baboon was the least represented in the shallow coastal zone 15-30m with a CPUA = 52.9 kg.km-2 and a biomass of 109.25 t. Highest CPUA values

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of 419 kg.km-2 were established in 30-50m depth lane with biomass 761 t, followed by of values of 234.3 kg.km-2 for CPUA and highest biomass values of 968 t depths of 50-100m.

Whiting (*Merlangius merlangus*)

The honeydew inhabits the layer near the bottom and feeds mainly on the sawdust. The species is a predator on the sawdust and is an important food component for the largest predators such as turbot and dolphins. In June 2019 was most strongly represented in the shallow coastal zone 15-30m with a CPUA = 270 $kg.km^{-2}$ and a biomass of 557 t., followed by a depth strip of 30-50m with a catch per unit area of 218 $kg.km^{-2}$ biomass of 396 t. , 115 $kg.km^{-2}$ for CPUA and 473 t biomass at depths of 50-100m.

Other species

Pontic shad (*A. Immaculata*)

Only single catches are present during the 2019 Spring Survey.

Round goby (*N. melanostomus*)

The species is benthic, coastal. Single specimens were recorded in catches.

Comments on **Tricone** (S.sprattus) biomass from different depth layers

The total biomass in June 2019 is 25903,47 tonnes for the Bulgarian Black Sea area.

Comments on ***Sprattus sprattus*** biomass from different depth layers

Table. 4.2.3. Sprat. Area Method in June 2019

CPUA mean	strata	Biomass (kg)	area	№ fields
1867,739	15-30	12496,55	2065,14	33
1730,739	30-50	7556,837	1814,82	29
1416,389	50-100	5850,084	4130,28	66
		25903,47	8010,24	128

Total biomass in June 2019is 25903,47tonnes for the Bulgarian Black Sea area.

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Catch predominance per unit area was 15-30m (1868kg.km^{-2})

Table. 4.2.2. Descriptive catch statistics for Sprattus sprattus June 2019

	30-50м	50-75м	75-100м
Mean	12496,6	7556,837	4972,173
Standard Error	1843,06	872,043	1556,601
Median	13223,9	7405,364	4760,591
Mode	15868,6	7405,364	#N/A
Standard Deviation	5212,95	4090,244	3480,666
Sample Variance	2,7E+07	16730096	12115033
Kurtosis	0,55498	5,109744	1,785545
Skewness	- 0,80827	1,654978	1,234005
Range	16397,6	19412,63	8992,227
Minimum	2644,77	1745,55	1586,864
Maximum	19042,4	21158,18	10579,09
Sum	99972,4	166250,4	24860,86
Count	8	22	5
Confidence Level(95.0%)	4358,14	1813,513	4321,817

Comments on the biomass of ***Mullus barbatus*** from different depth layers
Total biomass in June 2019 is 1837 tonnes for the Bulgarian Black Sea area. The lowest CPUA was registered at depths of 15 till 30m.

Table. 4.2.3. Red mullet. Area Method in December 2018

CPUA средно	**страти**	**Биомаса (kg)**	**Площ**	**Полета**
52,9	**15-30**	**109,2459**	**2065,14**	**33**
419,0947579	**30-50**	**760,5815**	**1814,82**	**29**
234,2513002	**50-100**	**967,5235**	**4130,28**	**66**
		1837,351	**8010,24**	**128**

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Table. 4.2.4. Red mullet. Descriptive statistics of biomass indices (t) June 2019

	15-30m	30-50m	50-100m
Mean	13.22386	247.6469	234.2513
Standard Error	8.657051	81.79633	138.4441
Median	0	52.89545	105.7909
Mode	0	0	52.89545
Standard Deviation	24.48584	383.6588	366.2886
Sample Variance	599.5562	147194.1	134167.4
Kurtosis	-1.8E-15	0.69906	6.624525
Skewness	1.440165	1.492221	2.553935
Range	52.89545	1057.909	1005.014
Minimum	0	0	52.89545
Maximum	52.89545	1057.909	1057.909
Sum	105.7909	5448.232	1639.759
Count	8	22	7
Confidence Level(95.0%)	20.47067	170.1048	338.7605

Comments on the biomass **of *M.merlangus*** from different depth layers

Table. 4.2.3. Whiting. Area Method in June 2019

CPUA mean	strata	Biomass (kg)	area	No.fields
269,7668199	15-30	557,1063	2065,14	33
218,1937514	30-50	395,9824	1814,82	29
114,6068189	50-100	473,3583	4130,28	66
		1426,447	8010,24	128

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Table. 4.2.6. Whiting. Descriptive statistics of biomass indices in June 2019

	30-50м	50-75м	75-100м
Mean	168,6043	158,6864	98,23442
Standard Error	95,35045	33,92143	33,51087
Median	66,11932	132,2386	52,89545
Mode	0	264,4773	52,89545
Standard Deviation	269,6918	159,1056	88,66143
Sample Variance	72733,67	25314,6	7860,849
Kurtosis	5,168391	0,727612	1,268084
Skewness	2,207363	1,050908	1,201291
Range	793,4318	528,9545	264,4773
Minimum	0	0	0
Maximum	793,4318	528,9545	264,4773
Sum	1348,834	3491,1	687,6409
Count	8	22	7
Confidence Level(95.0%)	225,468	70,54348	81,99814

Проектно предложение № BG14MFOP001-3.003-0001, „Събиране, управление и използване на данни за целите на научния анализ и изпълнението на Общата политика в областта на рибарството за периода 2017-2019 г.“, финансирано от Програмата за морско дело и рибарство, съфинансирана от Европейския съюз чрез Европейския фонд за морско дело и рибарство.

4.3. Catch per unit area

The calculated area-by-catch (CPUA) for the Bulgarian Black Sea area of the deep layers is presented in Fig. 4.2.1.

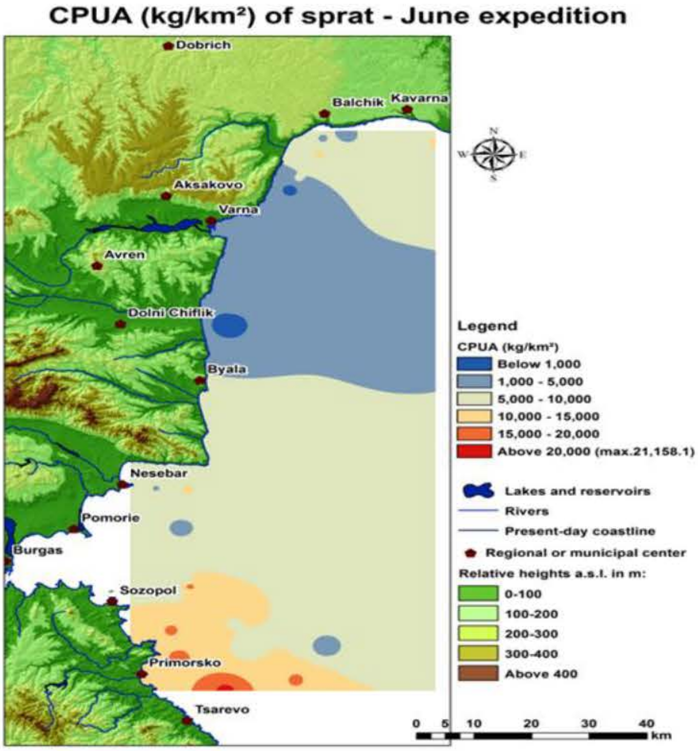

Figure 4.2.1. CPUA kg.km-2 of sprat for June 2019 of the surveyed areas

Sprat, June, CPUA kg.km-2 and biomass (t)
The highest values of the CPUA kg.km-2 of the sprat were recorded in a depth layer of 30-50m (21 158), followed by a depths of 15-30m (15 868.64) in the southern part of the surveyed area - north of Tzarevo. similar high values in front of Primorsko and south of Sozopol. Relatively lower CPUA values were established at greater depths of 50-100m, namely an average catch per unit area of 3552 kg.km-2

Whiting, June, CPUA kg.km-2 and CPUE kg.h
In June 2019, the highest values> 700 kg.km-2 of CPUA of whiting were regressed in front of Nessebar and Primorsko (Figure 4.3.3.). In the 30-50m lane, the highest catch per unit area was 528 kg.km-2, again in the area described in this study. At depths of 50-100m, the average catch per unit area was significantly lower, from 98 kg.km-2

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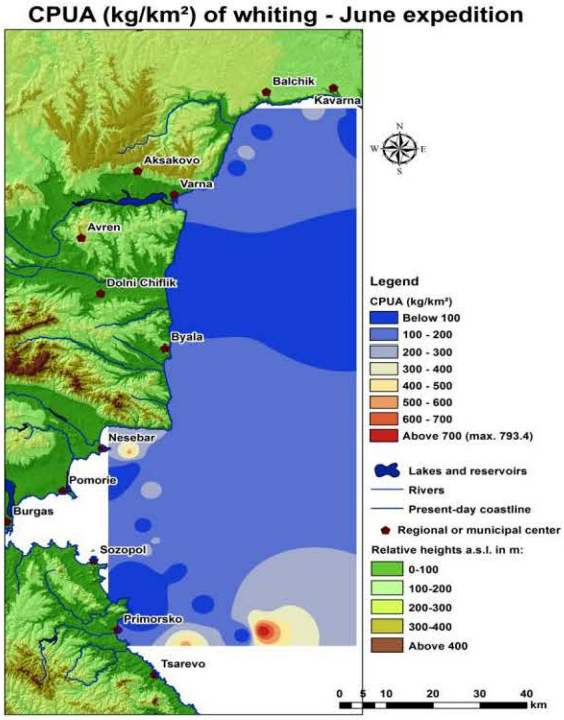

Figure 4.3.3. CPUA kg.km^{-2} of whiting of the surveyed area.

The highest catch per unit area was recorded at a depth of 50m southeast of Pomorie. (CPUA = 5679 kg.km-2). In the Nesebar bay and in the Cape Oyster region at depths of 29-30m, a CPUA = 2560kg.km-2 and a depth of 62m - CPUA = 1955kg.km-2

Red mullet June, CPUA kg.km^{-2}

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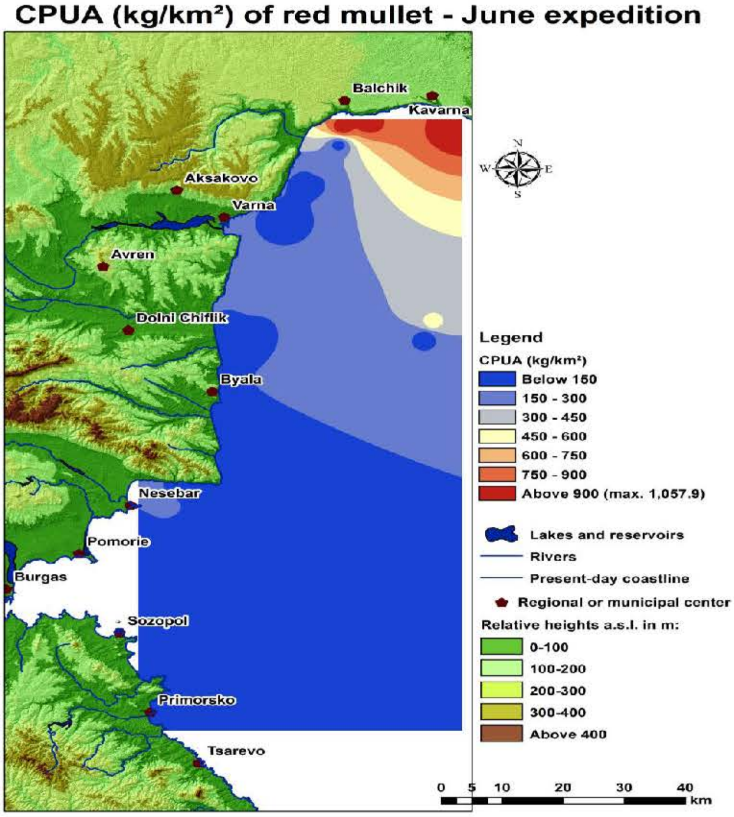


Figure 4.3.4. CPUA kg.km^{-2} of whiting of the surveyed area.

The catch per unit area and perch in the June 2019 survey (Figure 4.3.4.) Indicates that CPUAs in most of the studied waters are below 100 kg.km-2. An exception is the area in front of Blachik and Kavarna, where catches per unit area of 1058 kg.km-2 are recorded in the 30-50m strip.

4.4. Catch per unit of effort

Catches per unit of effort for identified species are presented graphically and spatially identified and analyzed by GIS.

CPUE kg.h-1 values for Trison, June 2019 - Pelagic trawl survey presented on fig.4.4.1

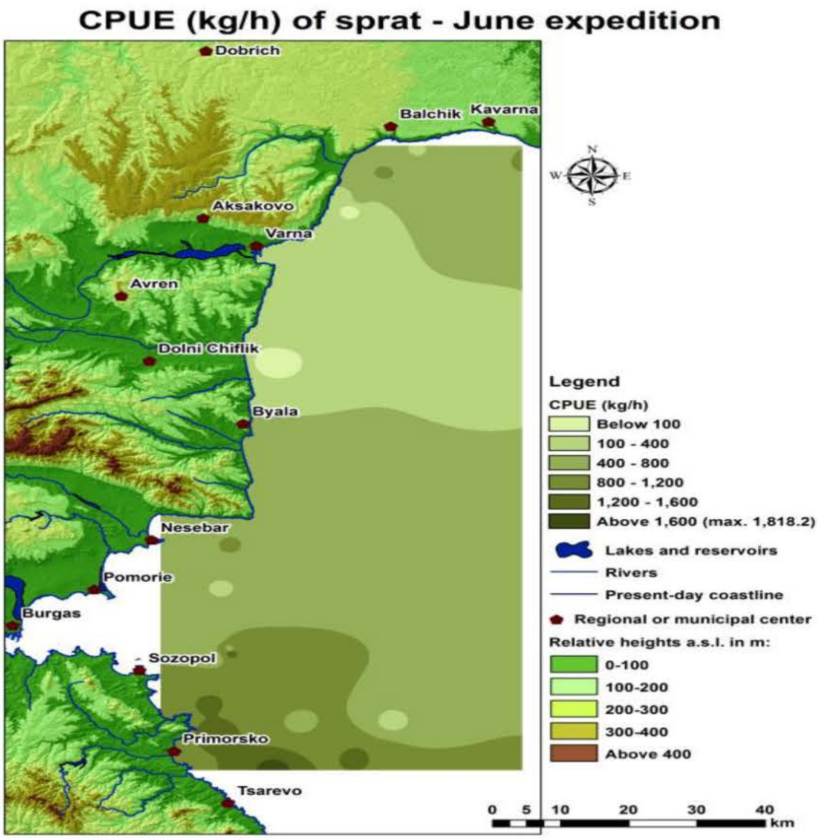


Figure 4.4.1. CPUA kg/h for sprat, June 2019

Проектно предложение № BG14MFOP001-3.003-0001, „Събиране, управление и използване на данни за целите на научния анализ и изпълнението на Общата политика в областта на рибарството за периода 2017-2019 г.“, финансирано от Програмата за морско дело и рибарство, съфинансирана от Европейския съюз чрез Европейския фонд за морско дело и рибарство.

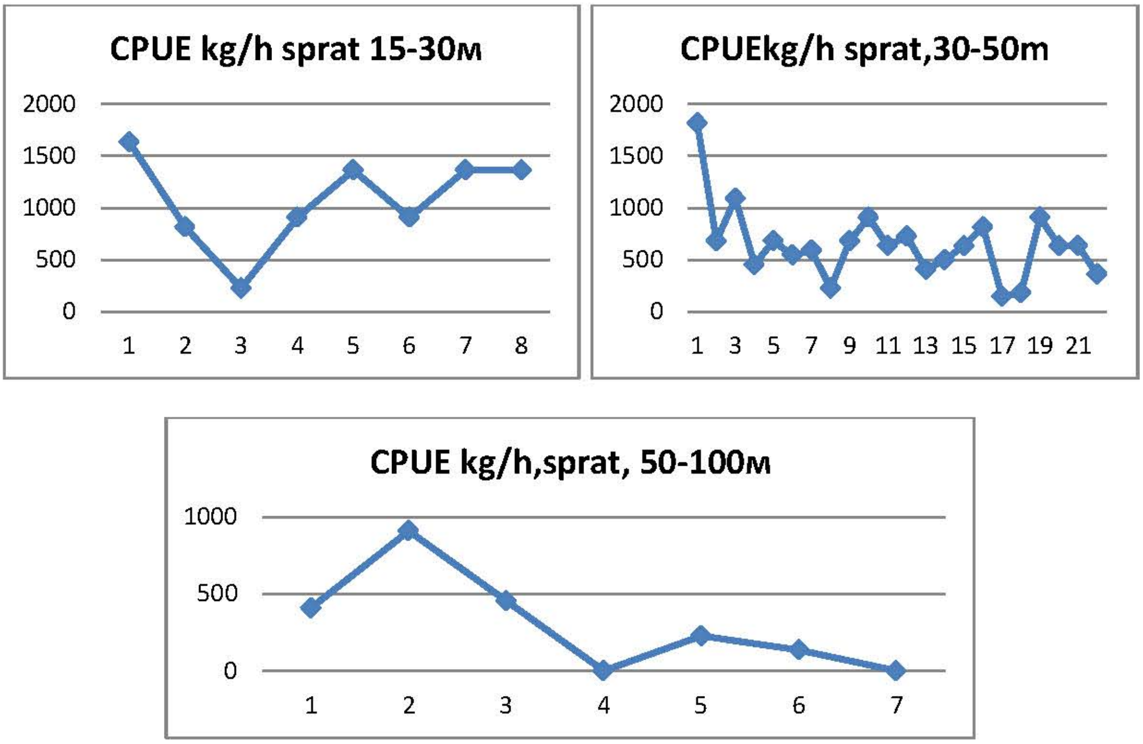


Figure 4.4.2. CPUE kg.h^{-1} values for sprat from June 2019

CPUE kg.h^{-1} values for whiting from June 2019 - pelagic trawl survey presented in Fig. 4.4.2.

Проектно предложение № BG14MFOP001-3.003-0001, „Събиране, управление и използване на данни за целите на научния анализ и изпълнението на Общата политика в областта на рибарството за периода 2017-2019 г.“, финансирано от Програмата за морско дело и рибарство, съфинансирана от Европейския съюз чрез Европейския фонд за морско дело и рибарство.

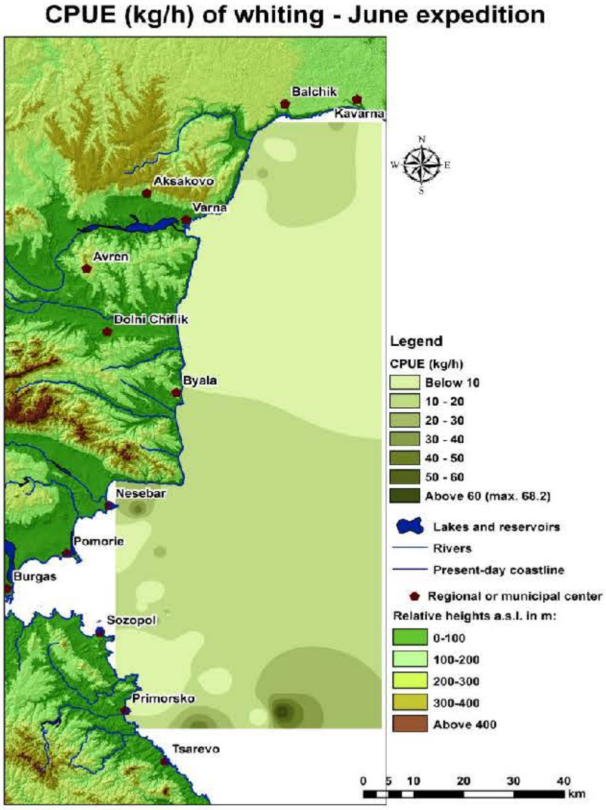
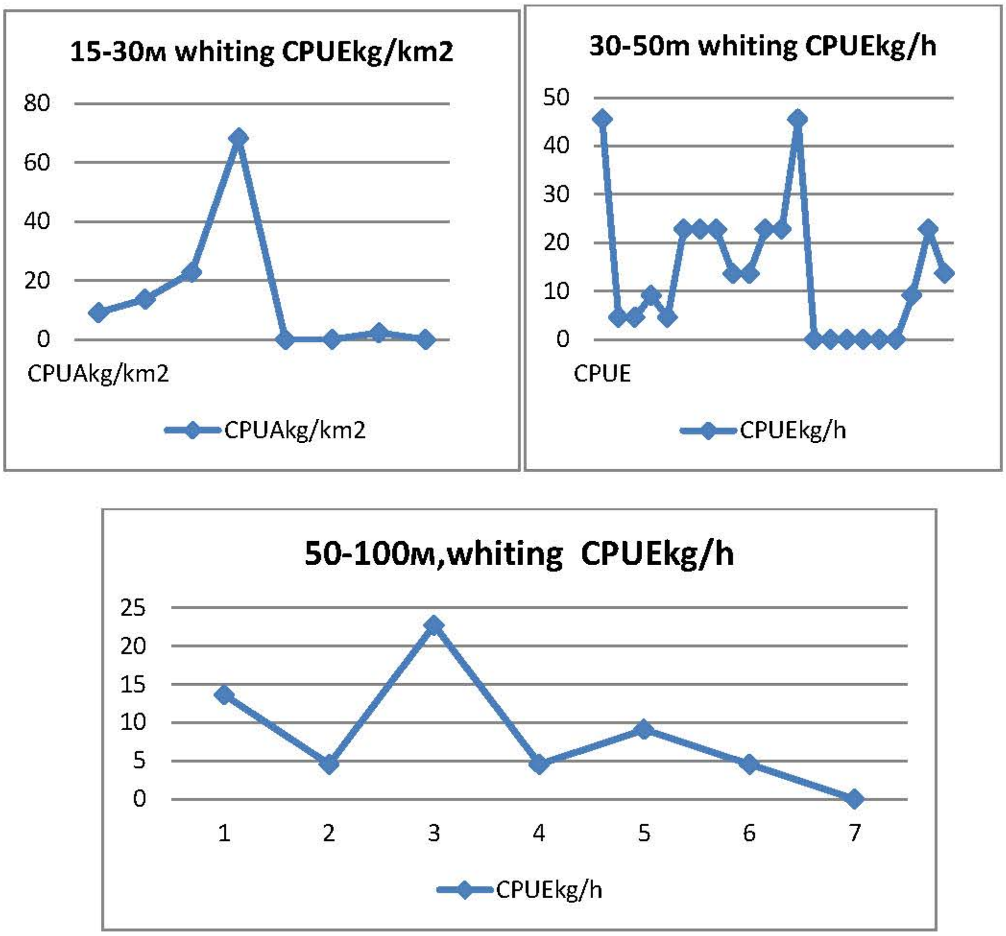


Figure 4.4.2. GIS represantation of whiting CPUE kg.h^{-1}

Проектно предложение № BG14MFOP001-3.003-0001, „Събиране, управление и използване на данни за целите на научния анализ и изпълнението на Общата политика в областта на рибарството за периода 2017-2019 г.", финансирано от Програмата за морско дело и рибарство, съфинансирана от Европейския съюз чрез Европейския фонд за морско дело и рибарство.



Fiure.4.4.3. CPUE kg.h-1 values for the whiting from June 2019 - pelagic trawl survey

Проектно предложение № BG14MFOP001-3.003-0001, „Събиране, управление и използване на данни за целите на научния анализ и изпълнението на Общата политика в областта на рибарството за периода 2017-2019 г.“, финансирано от Програмата за морско дело и рибарство, съфинансирана от Европейския съюз чрез Европейския фонд за морско дело и рибарство.

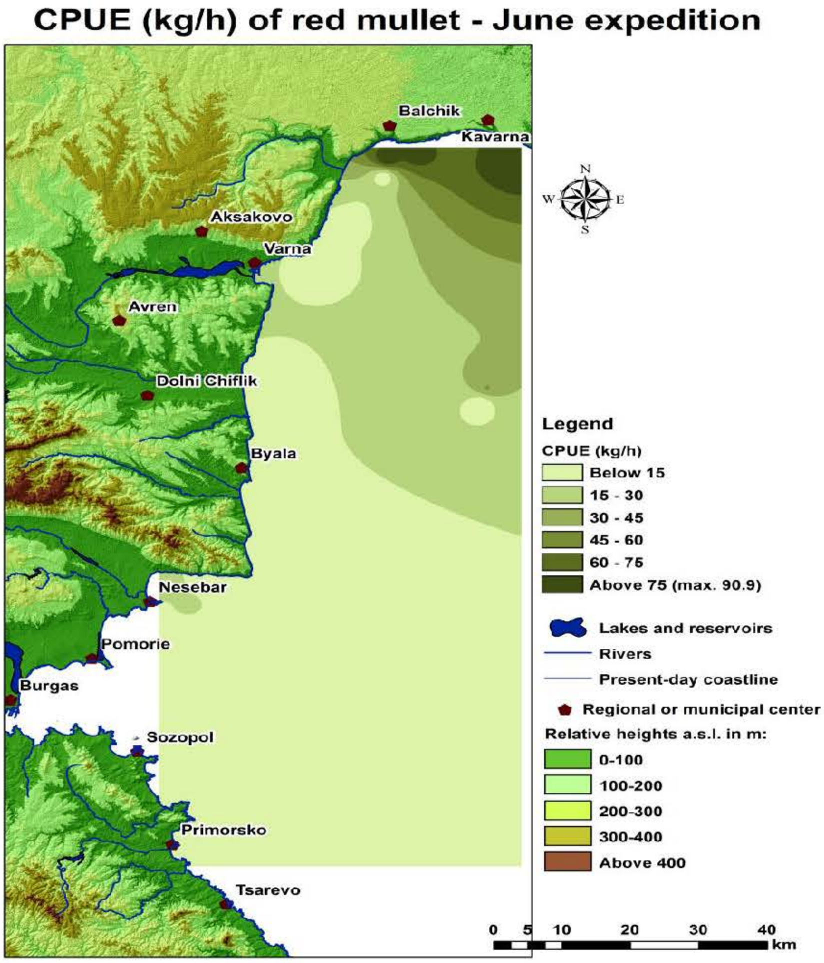


Figure 4.4.4. CPUE kg.h-1 GIS presentation of red mullet

Проектно предложение № BG14MFOP001-3.003-0001, „Събиране, управление и използване на данни за целите на научния анализ и изпълнението на Общата политика в областта на рибарството за периода 2017-2019 г.“, финансирано от Програмата за морско дело и рибарство, съфинансирана от Европейския съюз чрез Европейския фонд за морско дело и рибарство.

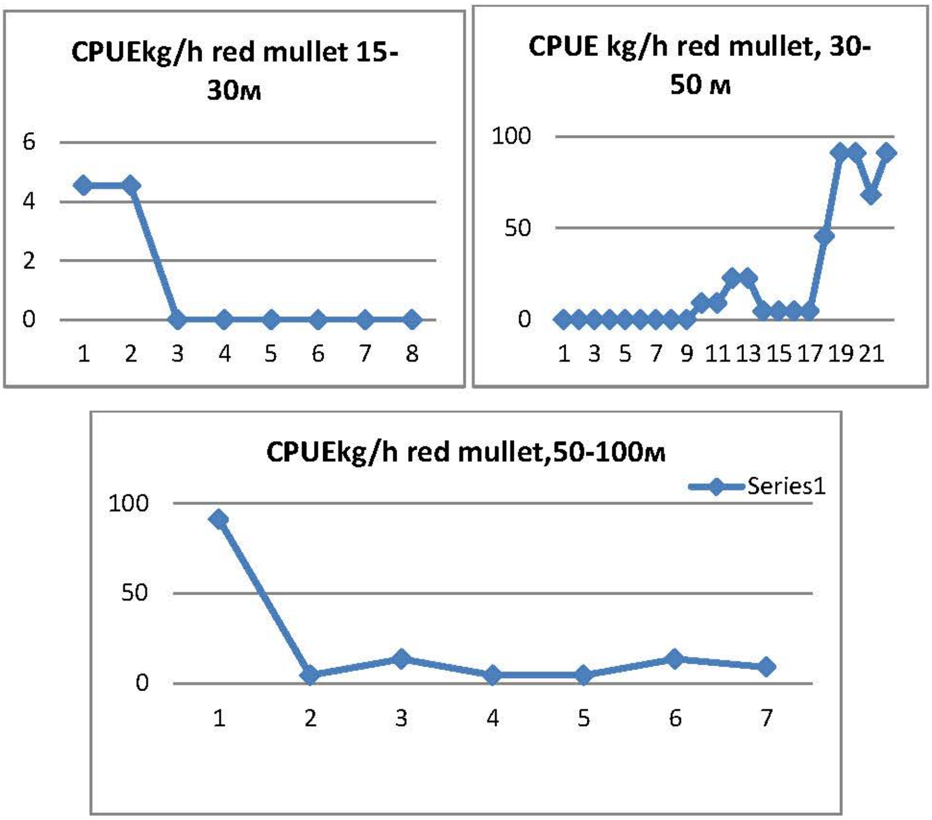


Figure 4.4.4. Red mullet CPUE kg.h-1 of the study area

4.5. Size structure of Sprattus sprattus, Red mullet and Whiting

Frequencies and average weights from different stations

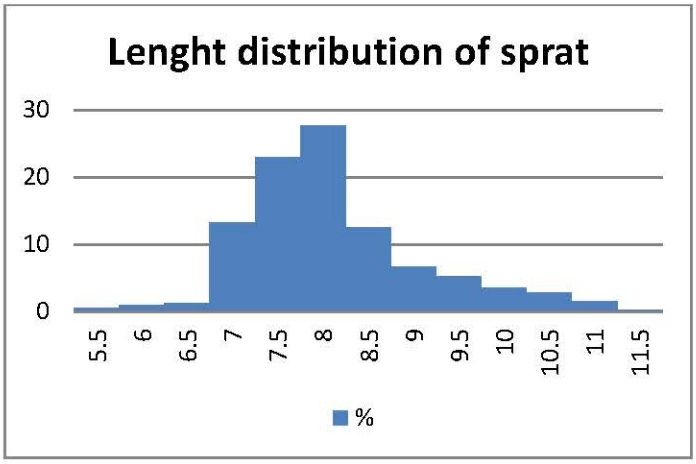


Figure 4.5.1. Lenght distribution of sprat

Lenght distribution of sprat in June 2019 has maxima at 8cm, followed by 7.5 cm amd 7 cm.The rest of the enght groups show less percentage, below 10% in the total samples measured. It is obvious that size classes 7.5-8 cm are dominant, with older classes being represented with a low percentage. The situation with the lack (or low share) of the older (the most senior) individuals is the same in the period 2007-2018 (Raikov et al., 2018).

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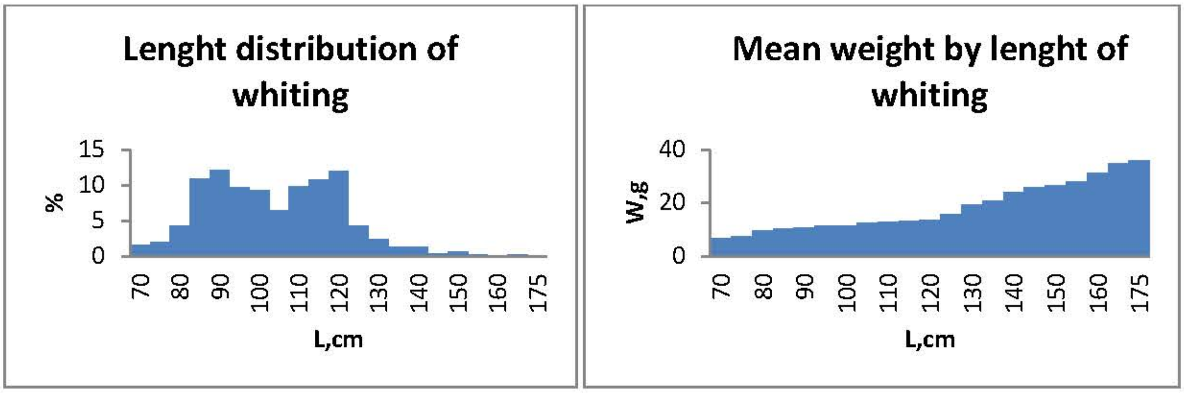

Fig. 4.5.1. Lenght and weight distribution of whiting

Bimodal groups maxima have been registered in June 2019, 8.5-9 and 11-12.5 cm sizes been predominant in the samples.

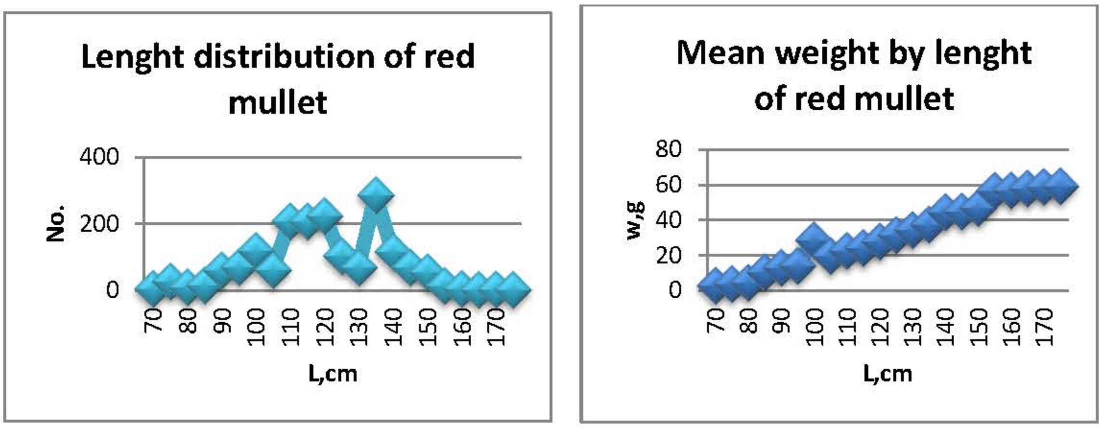

Fig. 4.5.2. Lenght and weight distribution of red mullet

Bimodal distribution have been observed for red mullet, as 11.0, 11.5, 12.0 and 12.5 cm groups, followed by highest maxima at 14.0 cm have been observed in the samples from survey in June 2019.

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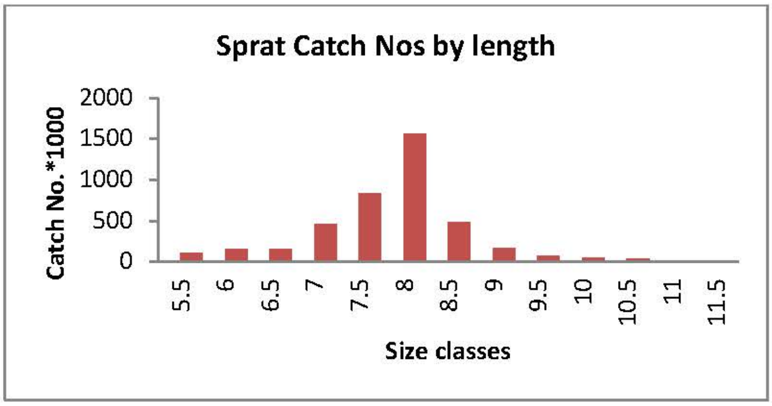

Figure 4.5.3. Catch numbs of sprat by size classes of from the Bulgarian marine zone, june 2019

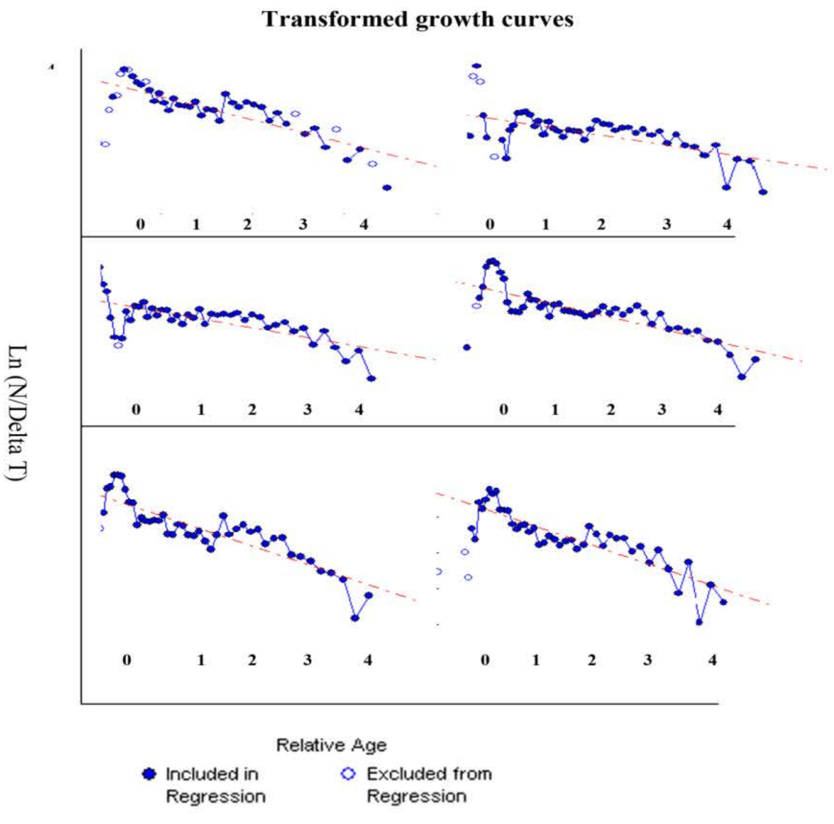

Fig. 4.5.5. Sprat curve growth curves of the sprat from June 2019

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4.6. Age structure

The age structure is determined on the basis of direct reading of the otoliths with the binocular of the reflected light. The analysis shows that the percentage of annuals is the highest in the present study (Fig.4.6.1.A, B.)

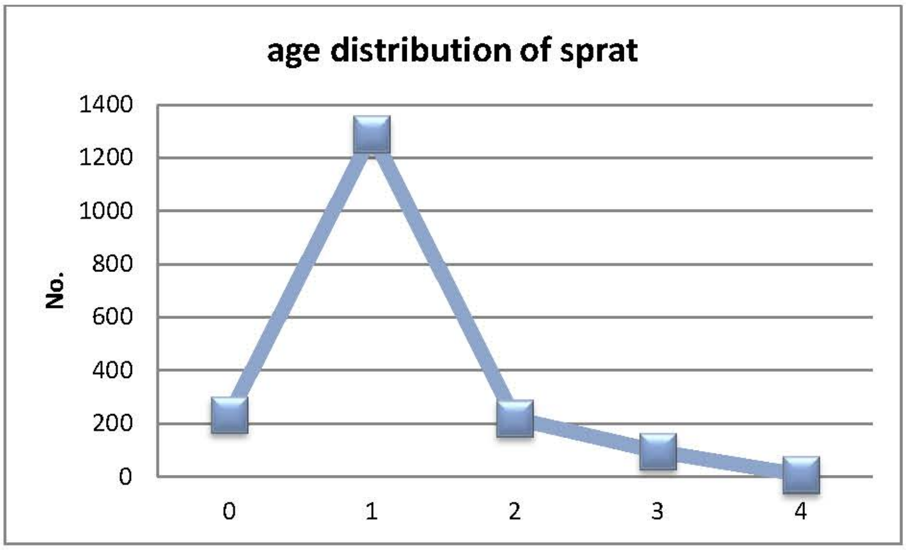

Fig.4.6.1.A. Distribution by age of sprat in June 2019

In June, 2019 the bulk of age disribution of sprat belong to 1-1+ years old.The rest of the age groups have low persentage.

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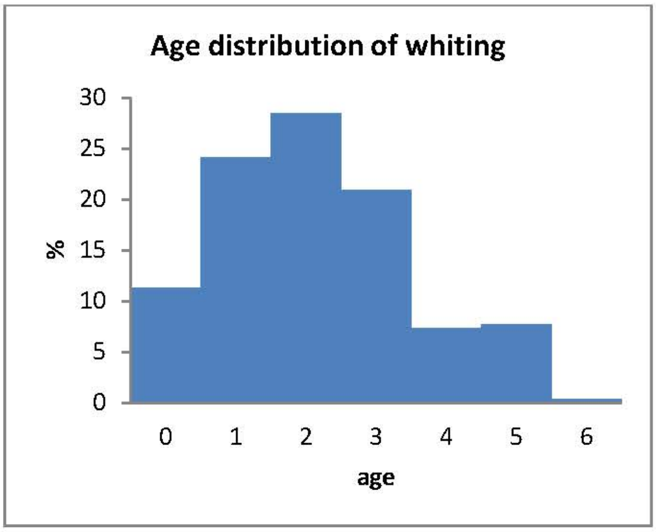

Fig.4.6.1.B. Distribution by age of whiting in June 2019

The age maxima for whiting belong to 2-2+ years old specimen, followed by 1-1+ and 3-3+ olds.The eldest aage groups have subordinate representation in the catches.

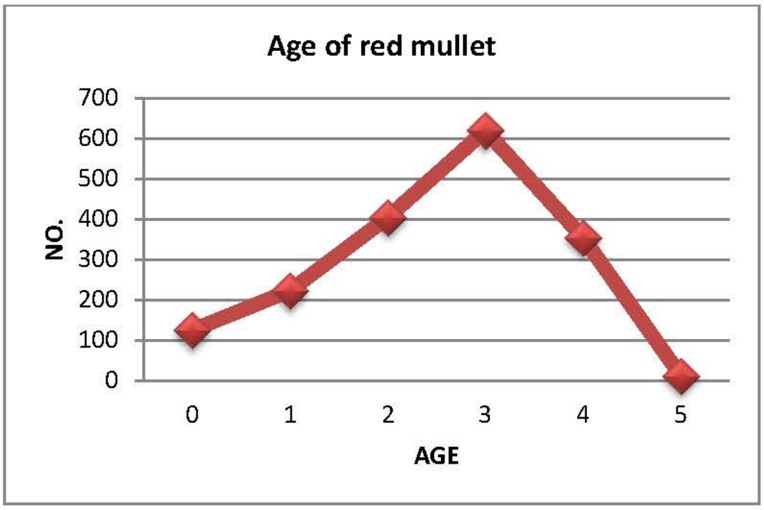

Fig. 4.6.2. Distribution by age of red mullet in June 2019

The predominant age of the red mullet was 3-3+ , followed by ages 2-2+ and 3-3 +

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Senior age and juvenile forms were present with a low percentage.

4.7. Growth

L growth

To calculate the growth rate and growth parameters from the Bulgarian area, we used the Von Bertalanfi equation, VBGF. The estimation of asymptotic length, growth rate and coefficients related to the coefficients is presented in Table 4.7.1.

Table 4.7.1. Parameters in the VBGF for sprat.

$L\infty$ = 12.03
k=0.45
t_0 = -2.0003
q = 0.009
n = 2.77

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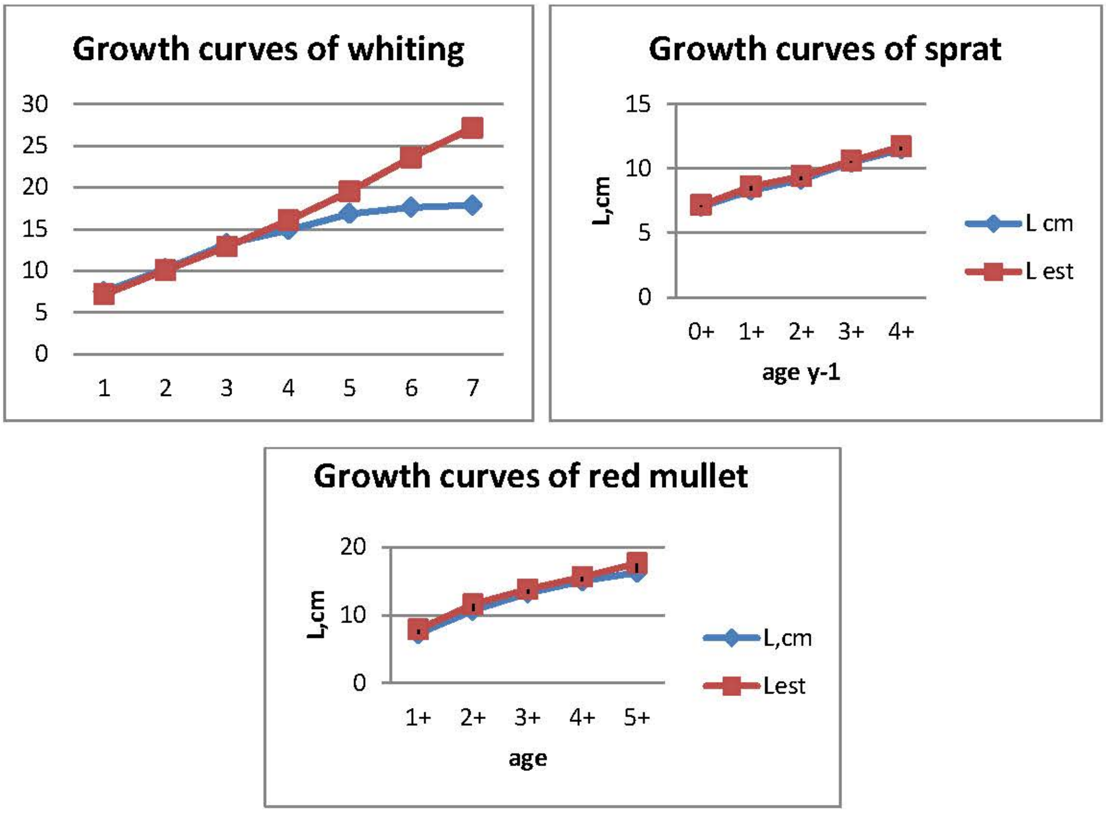

Fig.4.7.1. L asymptotic for sprat, whiting and red mullet

The asymptotic length reaches 12.03 cm; the rate of growth can be determined as being relatively high 0.45 y-1. The growth of sputum from the present study is positive allometric (n = 2.77) (Fig.4.7.1).

he most important note here is that because of the lack (or low share) of the oldest large age groups, the asymptomatic size function shows a relatively low value. In this regard, the maximum or asymptotic length reaches this value, which is probably not fully consistent with the literature data on the size of the species and the marginal length and growth rates. Therefore, we can accept the growth analysis as this is what reflects in the current situation of absence (low presence) of large individuals.

Body growth

The somatic growth of sprat from current research shows that the average

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the weight corresponding to the oldest age group is 8.05 grams. The value corresponds to the marginal size of 11.75 cm measured in samples from the trawl survey in Bulgarian waters (Fig.4.7.2).

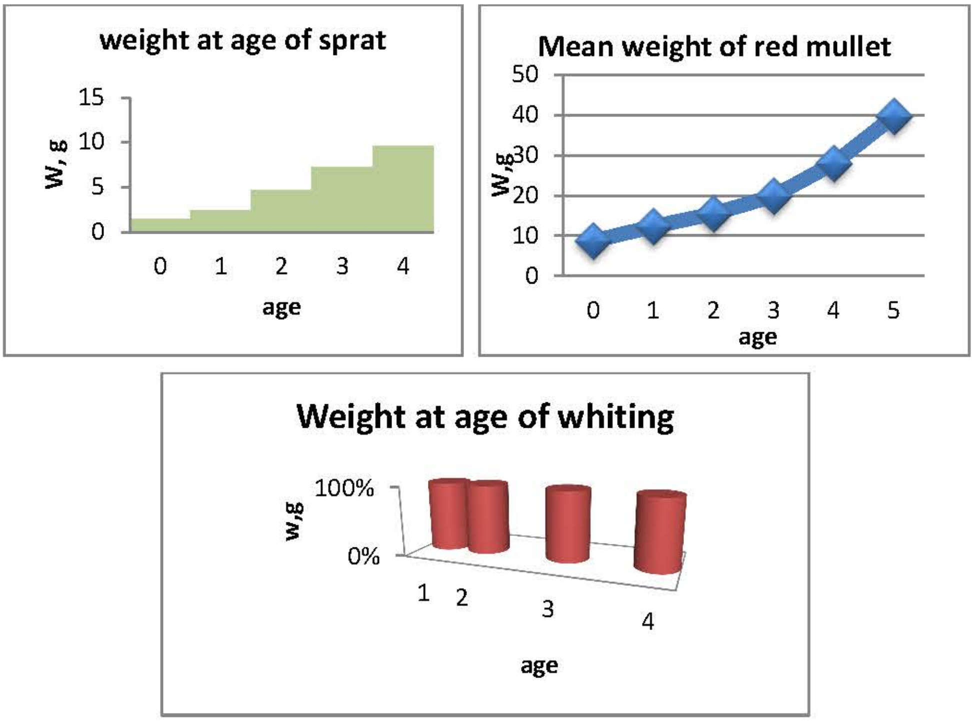

Fig.4.7.2. W asymptotic for sprat red mullet and whiting

4.8. Sex Ratio

For sprat females predominate by 50%, followed by males (49%). Juveniles were represented with a low percentage (1%)

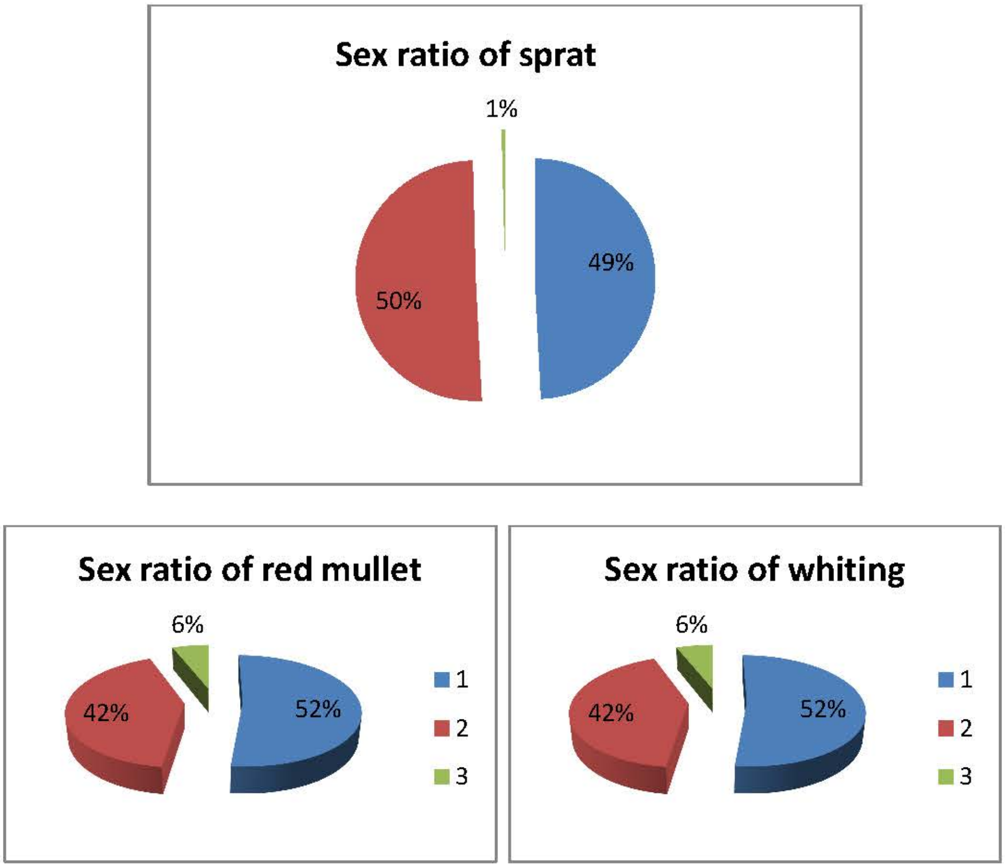

Figure 4.8.1. Sex ratio1 - male; 2 - female; 3 - juvenile

4.9. Fertility and fecundity

Spart was not active in the spawning phase of the current investigation in June. Most of the individuals have stage I-II, III glands. A more detailed analysis should be made in the active spawning period of the species (October-February)

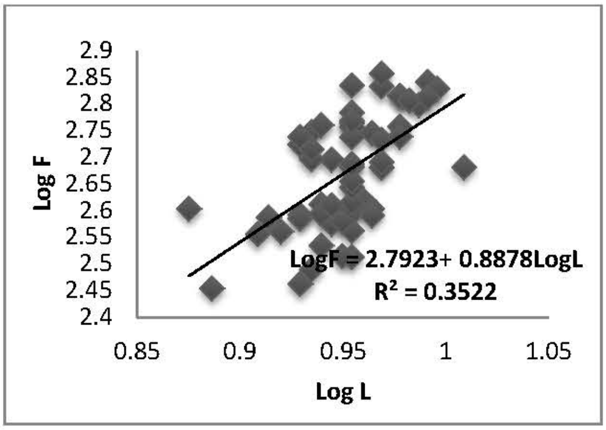

Figure 4.9.1. Fecundity Plot (LogF) in relation to the size (LogL) of the sprat from the June 2019 study.

Sprat fecundity correlates poorly with its length (R^2 = 0.3522).

4.10. Gonado-somatic index

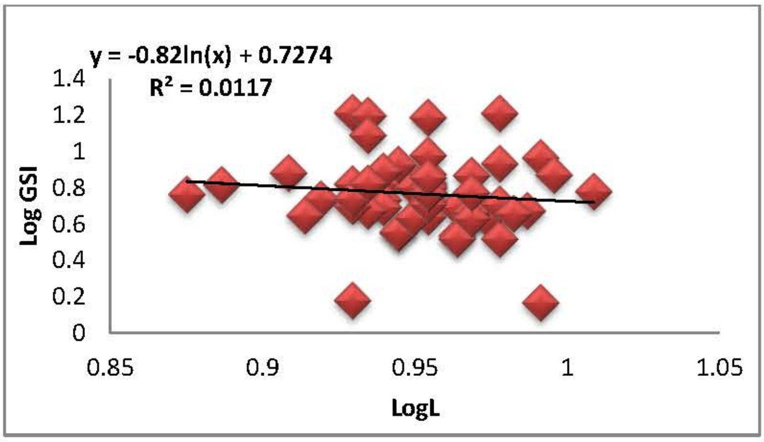

Figure 4.10.1. Gondo-somatic index of the sprat of this study (GSI,%)

GSI (%) indicates that a small percentage of females are actively breeding. Most individuals were in the early stages of maturation, so we can conclude that in June 2019, active reproduction did not begin.

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5. Length-weight dependence, Index of stomach fullness (ISF)

The mean absolute length of investigated sprat specimens reached 7.51 cm ± 0.67 (SD), varying between 6.20 - 9.60 cm, correspondingly the mean weight was 2.47 g ± 0.81 (SD), ranging from 1.28 g to 5.21 g (Table 5.2, Fig 5.1).

Table 5.2. Summary statistics of sprat length (L, cm), weight (W, g) and ISF (% BW), analysed for stomach content composition during VI.2019.

	L, cm	W, g	ISF, % BW
Mean	7.51	2.47	0.80
Standard Error	0.06	0.08	0.05
Median	7.50	2.32	0.72
Mode	7.50	1.68	0.75
Standard Deviation	0.67	0.81	0.53
Sample Variance	0.45	0.65	0.28
Kurtosis	0.24	1.13	2.09
Skewness	0.64	1.15	1.45
Range	3.40	3.93	2.48
Minimum	6.20	1.28	0.06
Maximum	9.60	5.21	2.54
Sum	825.70	271.60	84.37
Count	110.00	110.00	106.00
Confidence Level (95.0%)	0.13	0.15	0.10

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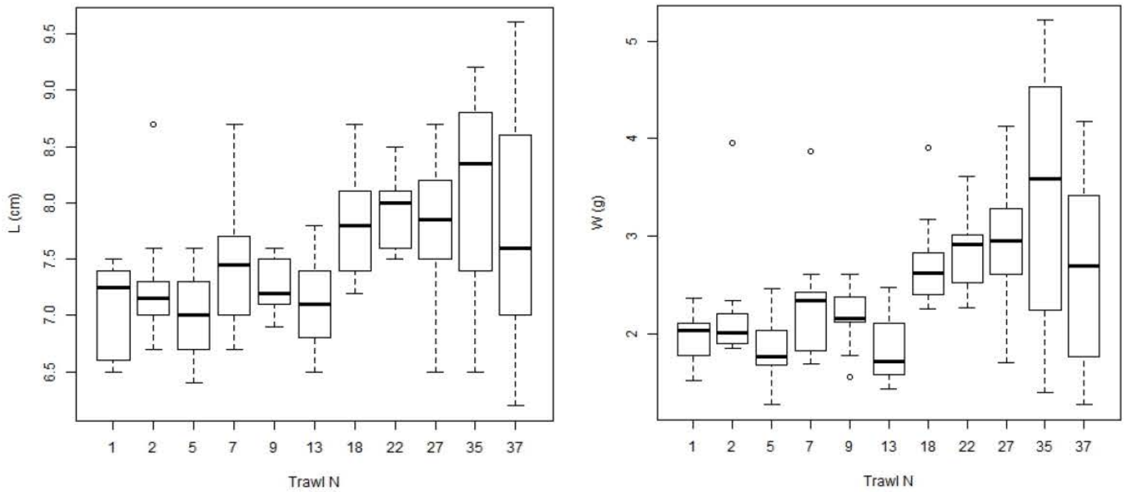

1. 2.

Figure 5.1. Box plot (median values, 25 – 75 % hinge, minimal and maximal values): distribution of sprat length (1, cm) and weight (2, g) per trawls during VI.2019.

The weight-length dependence for sprat could be described by the following equation: Log WW(g)=3.2522*Log L(cm) - 2.4697; ($R2=0.89$, $p<0.001$, Fig.5.2).

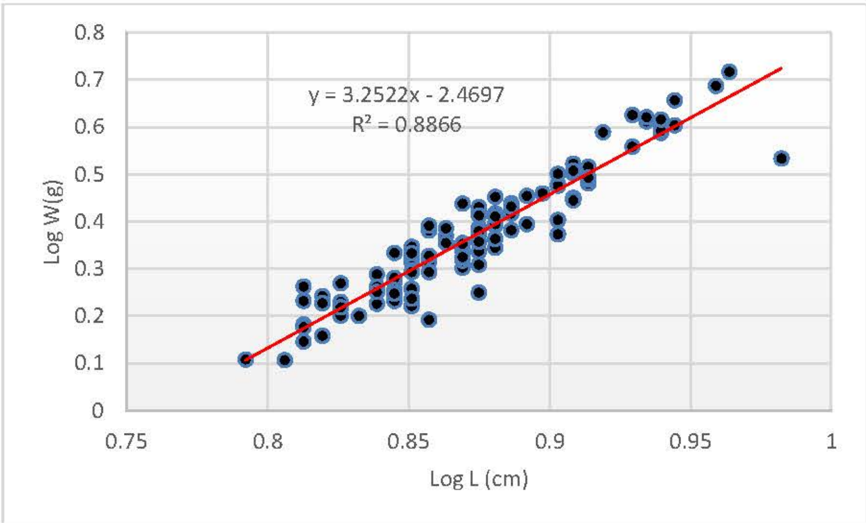

Figure 5.2. Sprat weight-length relationship in VI.2019.

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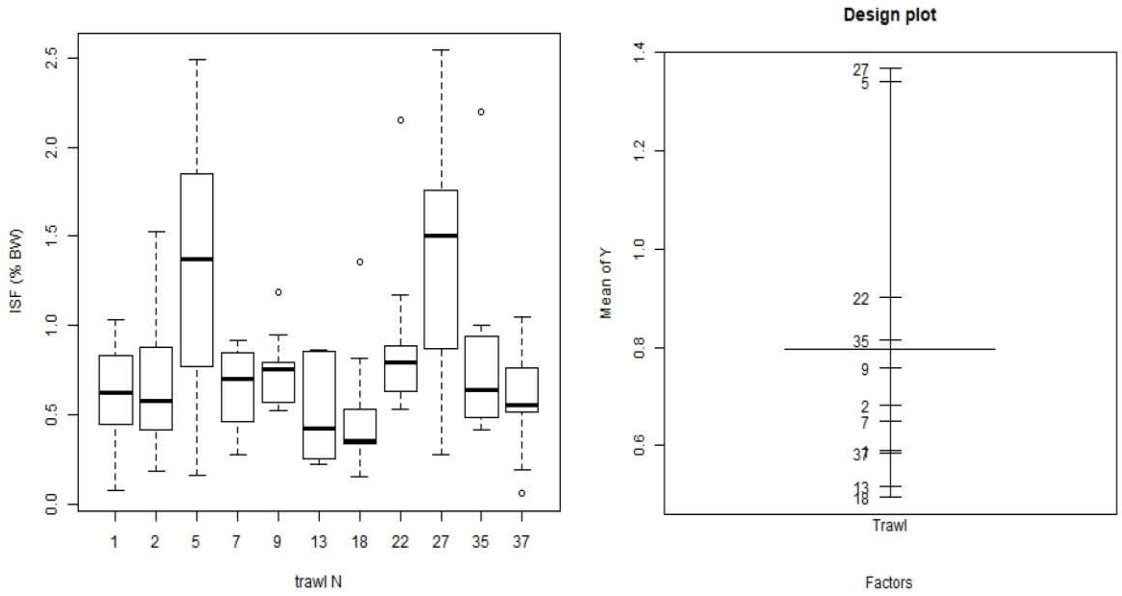
In June 2019, the average value of the index of fullness reached 0.80% ± 0.53 (SD) of the sprat weight (Table 5.2). ISFVI.2019 exceeded by 40.60% the average for springs 2007 - 2010 (0.53% BW).



1. 2.

Figure 5.3. (1) Boxplot: sprat index of stomach fullness (ISF, % BW) in June 2019. (2) Design plot: distribution of mean ISF (% BW) by trawls.

The highest average index of fullness - ISF ~ 1.4% was detected in trawls 5 and 27 - in front of Ahtopol and under the Cape Kalikara, at depths of 60 m and 16 m. The average values of ISF are minimal (~ 0.5% BW) in the shallow coastal area between Varna and Sozopol Bays (Fig. 5.4).

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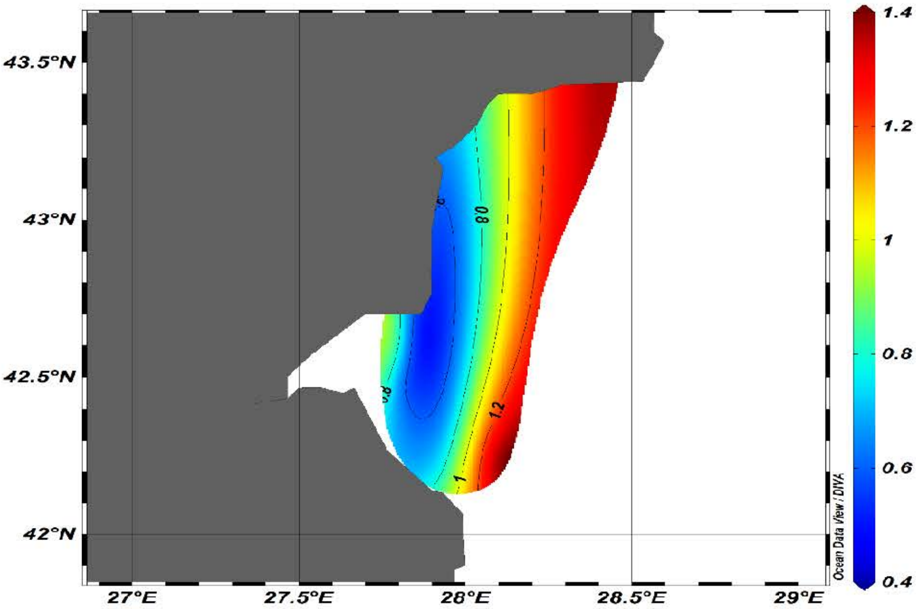

Fig. 5.4. Spatial distribution of ISF (% BW) in VI.2019.

Between ISF and sprat weight within the limits of 1.28 - 5.21 g was not established a statistically significant difference (Fig.5.5).

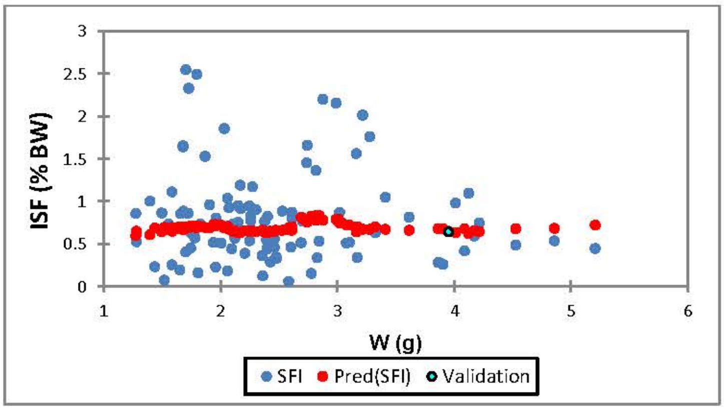

Figure 5.5. Relationship between sprat weight (WW, g) and ISF (% BW).

Prey number, species composition and index of relative importance (IRI) of mesozooplankton species in the sprat diet

The average prey number in the sprat diet amounted to 205.35 ind/stomach 260.39 ± SD off the Bulgarian coast. The maximal individual number of food organisms - 1055 ind/stomach was established near the Cape Kalikara (trawl 27, depth 16 m), by the average PN - 621 ind/stomach and maximal ISF - 1.34% BW, in connection with intensive consumption of Acartia clausi. A significant average PN - 554 ind/stomach was also established near to the Cape Maslen nos (trawl 9, depth 41 m), related to the consumption of Lamellibranchia veliger (Fig.5.6).

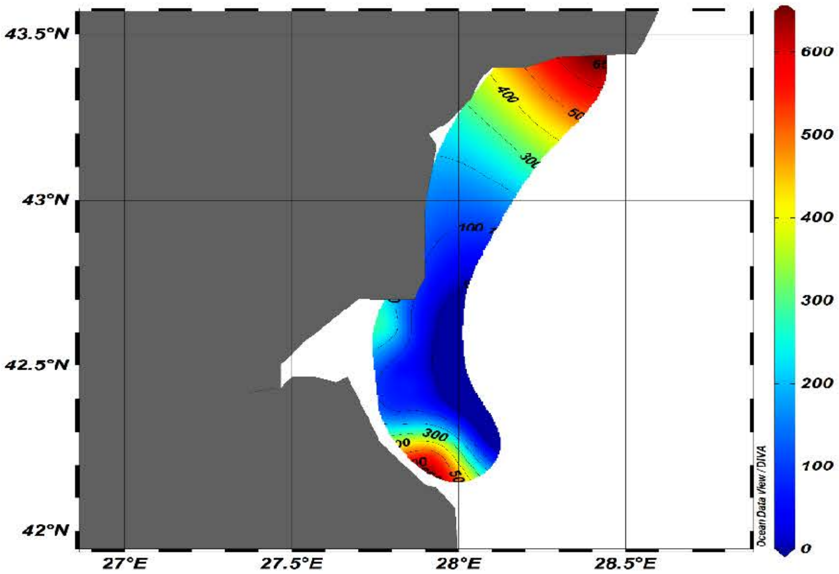

Fig. 5.6. Spatial distribution of the average prey number (PN) per trawls in VI.2019.

24 zooplankton species/groups were identified in the marine environment, and some of them - 19 species/groups were represented as food components in the sprat ration. The crustacean copepods were represented by several species: Calanus euxinus, Pseudocalanus elongatus, Paracalanus parvus, Acartia clausi, Centropages ponticus, Oithona spp., Harpactiocoida spp., Copepoda spp; five taxonomic groups of planktonic larvae of benthos organisms (meroplankton) were detected: Lamellibranchia veliger, Gastropoda veliger, Cirripedia larvae, Decapoda larvae, Polychaeta larvae; class Chaetognatha was represented by species

Parasagitta setosa, class Appendicularia - by Oicopleura dioica. In the sprat food were established single specimens of Pisces ova and Noctiluca scintillans.

The indices of relative importance (IRI) of the zooplankton species in sprat food spectrum (based on the percent shares from total abundance, biomass, and frequency of occurrence in samples) were represented in Table 5.3.

Table 5.3. The sprat food composition in VI.2019.

Състав на храната на трицоната	N (%, от общата численост)	M (%, от общата биомаса)	FO - Честота на срещане	IRI - Индекс на относителна значимост
Acartia clausi	19.17	35.44	72.73	3971.29
Lamellibranchia veliger	24.17	9.05	53.18	1766.62
Paracalanus parvus	6.57	5.49	69.77	841.44
Calanus euxinus	7.58	19.95	20.45	563.24
Pleopis polyphemoides	11.86	13.60	21.14	538.09
Cirripedia larvae	4.97	3.14	46.14	374.32
Oithona spp.	6.77	1.76	37.50	319.81
Oikolpeura dioica	2.79	1.10	45.00	174.86
Centropages ponticus	5.16	1.40	25.68	168.49
Decapoda larvae	0.93	4.14	25.45	128.97
Pseudocalanus elongatus	1.00	0.93	27.27	52.63
others	9.03	4.01		
total	100%	100%		

The sprat food was dominated by Acartia clausi, followed by Lamellibranchia

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veliger, Pseudocalanus elongatus, Paracalanus parvus and C. euxinus (Tabl.5.3 & 5.4, Fig. 5.7). The eurytherm species predominated the sprat diet by abundance and biomass and showed the highest frequency of occurrence.

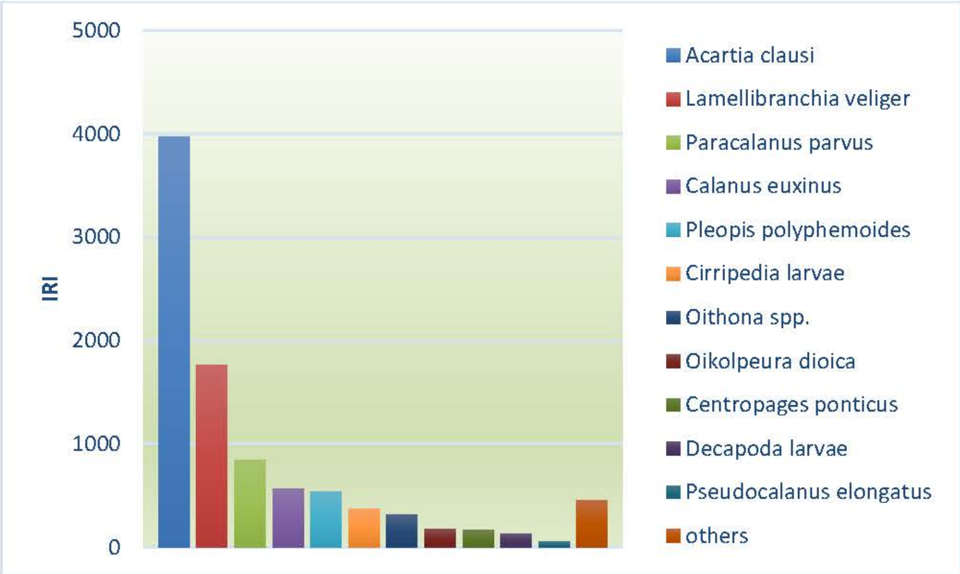

Figure 5.7. Mean IRI of mesozooplankton species in the sprat food during VI.2019.

The species A. clausi was well presented in sprat food samples from the northern and central regions, the species L.veliger was detected in the area Sozopol – Maslen nos; Paracalanus parvus was found in the sprat diet near to the Cape Emine, and the cold-water species C. euxinus was presented in open sea waters in the zone Kiten - Cape Maslen nos (Table 5.4 and Figure 5.8).

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Table 5.4. IRI (%) of mesozooplankton species in sprat food per trawls in June 2019.

Sprat diet components	1, 37 m	2, 39 m	5, 60 m	7, 42 m	9, 41 m	13, 36 m	18, 27 m	22, 31 m	27, 16 m	35, 21 m	37, 22 m
Acartia clausi	24.34	40.84	0.10	22.23	2.47	20.81	0.07	4.42	96.09	66.80	75.01
L. veliger	17.28	34.35	1.79	39.54	89.42	37.27	0.00	0.01	0.01	0.00	2.16
P. parvus	10.35	5.77	0.24	10.79	1.17	6.69	27.21	2.38	1.80	0.40	0.33
C. euxinus	1.53	14.90	94.46	14.13	1.50	0.00	0.17	0.00	0.00	0.00	0.59
P. polyphemoides	0.00	0.00	0.00	1.82	0.00	0.57	60.07	75.46	0.00	0.00	0.00
Cirripedia larvae	0.02	0.00	0.00	0.43	0.03	0.00	2.17	6.67	1.83	25.13	17.45
Oithona spp.	39.14	3.65	0.19	6.69	4.17	0.00	0.00	0.55	0.00	0.00	0.00
Oikolpeura dioica	6.39	0.05	0.02	1.86	0.43	4.18	4.15	3.50	0.00	0.00	0.01
C. ponticus	0.00	0.00	0.00	0.05	0.02	28.05	2.30	0.05	0.11	0.41	0.05
Decapoda larvae	0.00	0.00	0.00	0.00	0.00	0.00	2.76	6.21	0.15	7.07	3.51
Pseudocalanus elongatus	0.74	0.28	2.68	0.62	0.13	0.00	0.73	0.03	0.01	0.00	0.77
others	0.22	0.16	0.52	1.84	0.65	2.45	0.38	0.73	0.01	0.19	0.11
	100	100	100	100	100	100	100	100	100	100	100

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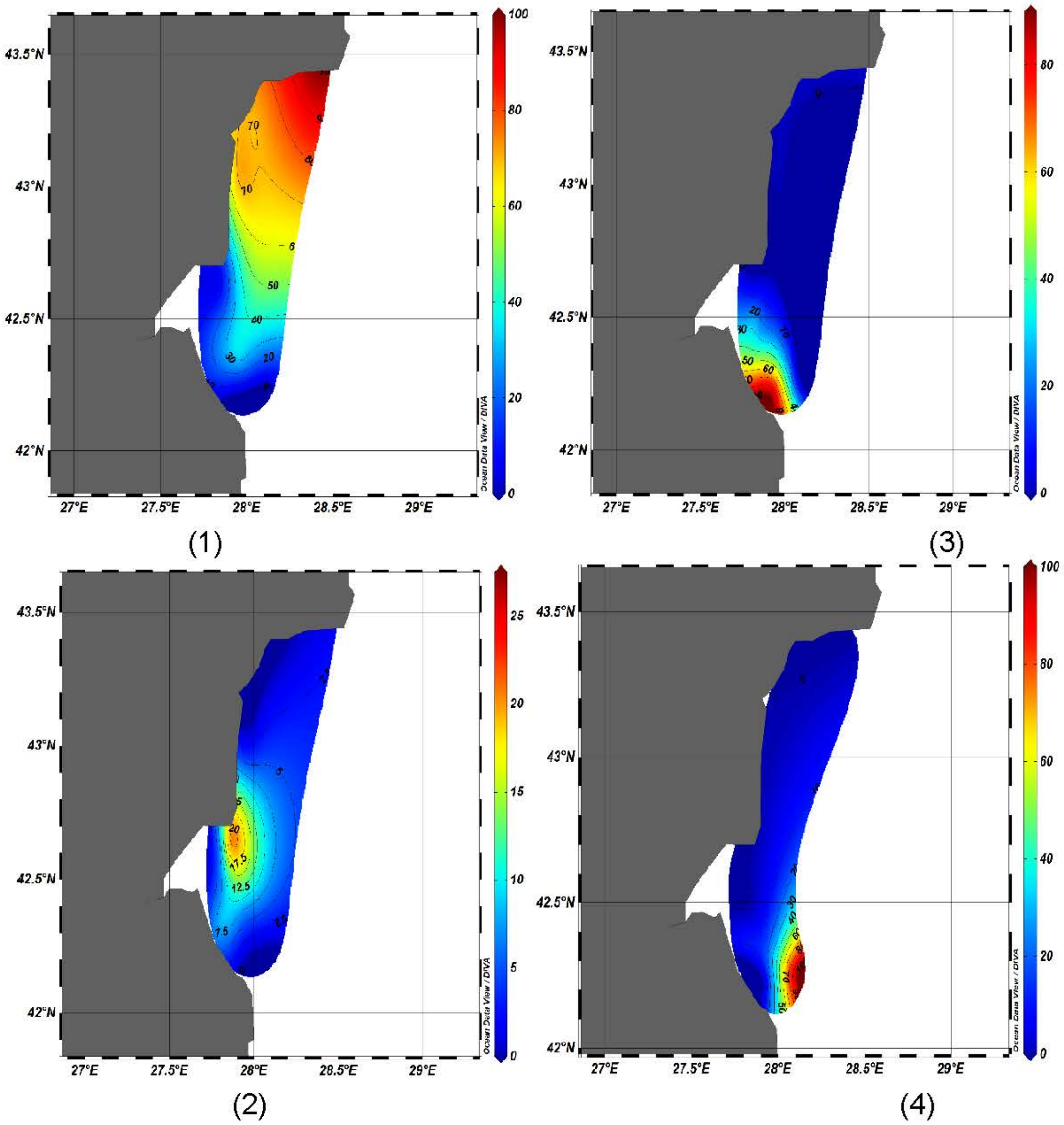

Figure 5.8. Spatial distribution of IRI (%) of mesoplankton species in sprat food - (1) A. clausi, (2) Paracalanus parvus (3) L.veliger и (4) Calanus euxinus during VI.2019.

Zooplankton in the marine environment: species composition and biomass

During the studied period, the zooplankton biodiversity was formed by 24 species

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(Table 5.6).

Table 5.6. Species diversity of zooplankton.

	VI.2019
1.	Noctiluca scintillans
2.	Ctenophora larvae
3.	Pleurobrachia pileus
4.	Aurelia aurita
5.	Acartia clausi
6.	Acartia tonsa
7.	Pseudocalanus elongatus
8.	Calanus euxinus
9.	Paracalanus parvus
10.	Centropages ponticus
11.	Oithona davisae
12.	Oithona similis
13.	Harpacticoida spp.
14.	Pleopis polyphemoides
15.	Cirripedia nauplii/cypris
16.	Lamellibranchia veliger
17.	Polychaeta larave
18.	Gastropoda veliger
19.	Nematoda Larvae
20.	Phoronis larvae
21.	Decapoda zoea/mysis
22.	Parasagitta setosa
23.	Oicopleura dioica
24.	Pisces ova, larvae

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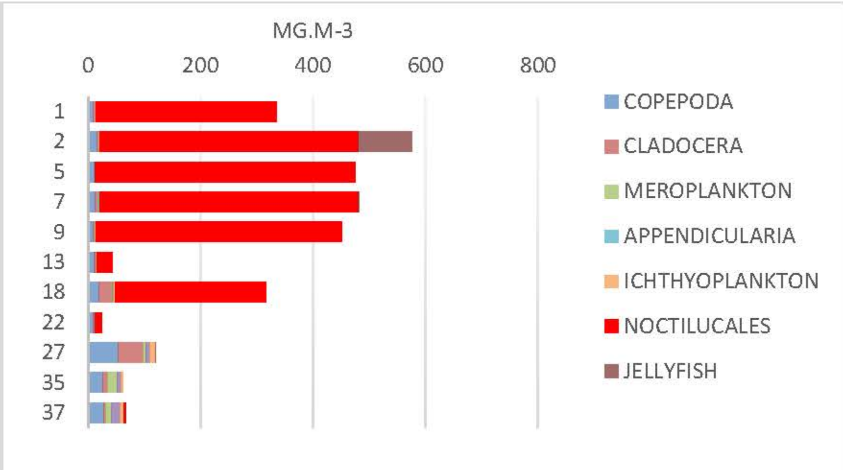
The species Noctiluca scintillans (Protozoa) played a dominant role in the total biomass formation - 83.10% (Fig. 5.11.1, Table 5.7), and the percentage of mesozooplankton (food zooplankton) reached 13.61%. The species N. scintillans and copepods predominated by abundance (Fig. 5.11.2) and formed 67.56% and 20.86% of the total zooplankton abundance, respectively.



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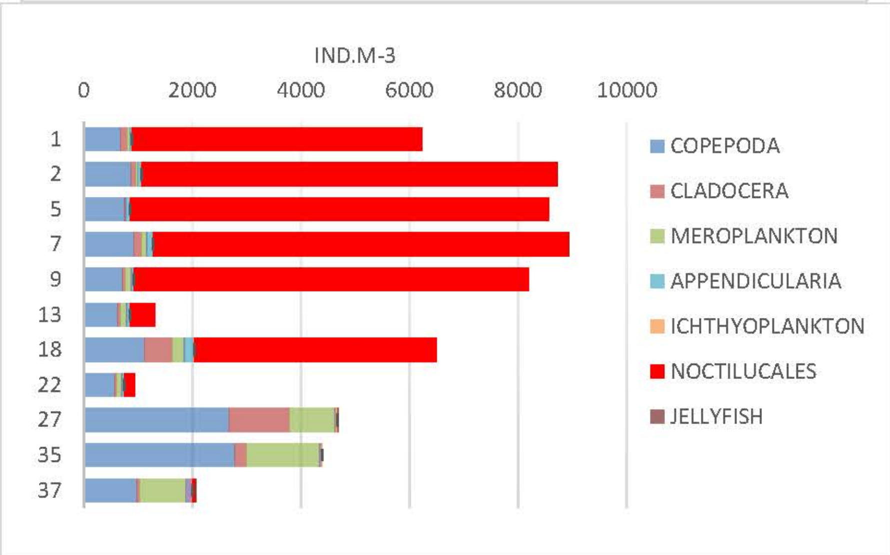

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Figure 5.11. Distribution of the biomass (1. mg.m-3)) and abundance (2, ind.m-3) of the main zooplankton groups (mg.m-3) per stations during June 2019.

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Table 5.7. Percentage distribution (%, from total biomass) of main zooplankton groups per stations during June 2019.

STATIONS	COPEPODA	CLADOCERA	MERO-PLANKTON	CHAETO-GNATHA	APPENDICULARIA	ICHTHYO-PLANKTON	NOCTILUCALES	JELLYFISH
1	2.76	1.31	0.07	0.09	0.05	0.00	95.73	0.00
2	2.77	0.58	0.01	0.05	0.06	0.05	79.85	16.62
5	2.12	0.20	0.00	0.07	0.13	0.06	97.42	0.00
7	2.44	1.12	0.33	0.16	0.12	0.05	95.53	0.25
9	2.17	0.61	0.18	0.03	0.04	0.06	96.90	0.00
13	23.80	3.59	3.02	2.37	0.52	1.31	65.38	0.00
18	6.19	6.64	0.84	0.32	0.29	1.06	84.66	0.00
22	37.09	5.33	3.14	2.06	0.77	3.38	48.22	0.00
27	44.48	36.88	4.79	4.78	0.00	8.80	0.00	0.27
35	43.02	13.91	27.98	10.71	0.00	4.38	0.00	0.00
37	41.69	3.89	15.43	24.84	0.00	8.31	5.83	0.01

Table 8 shows general statistical data about the total zooplankton biomass variability in June 2019, including three main groups – mesozooplankton, Protozoa, and jellyfish.

The total biomass of zooplankton amounted to 268.36 mg.m-3 ± 63.13 (SE), with the biomass of the protozoan species N. scintillans reaching 223 mg.m-3 ± 64.46 (SE) and of the mesozooplankton biomass - 36.52 mg.m-3 ± 10.24 (SE). The total biomasses of food mesozooplankton and jelly species were assessed as relatively low for the season.

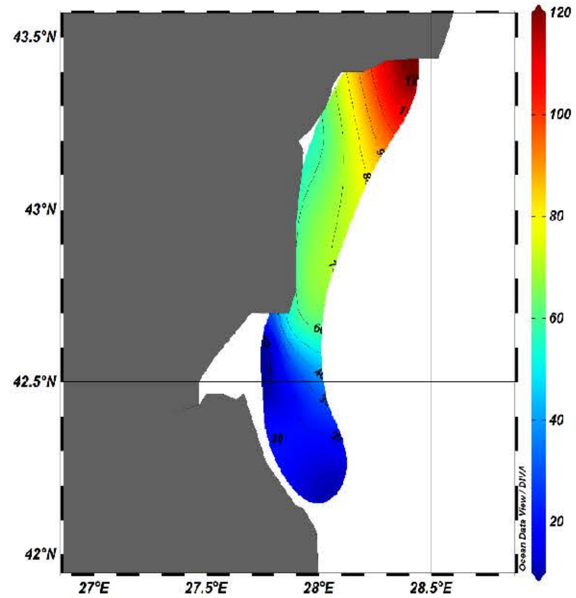
Проектно предложение № BG14MFOP001-3.003-0001, „Събиране, управление и използване на данни за целите на научния анализ и изпълнението на Общата политика в областта на рибарството за периода 2017-2019 г.“, финансирано от Програмата за морско дело и рибарство, съфинансирана от Европейския съюз чрез Европейския фонд за морско дело и рибарство.

Table 5.8. Statistical data about biomasses (mg.m-3) of the main zooplankton groups in June 2019.

	Meso-zooplankton	Protozoa	Jelly-plankton	Total zooplankton biomass
Mean	36.52	223.00	8.84	268.36
Standard Error	10.24	64.46	8.69	63.13
Median	20.29	268.26	0.00	316.85
Mode	#N/A	0.00	0.00	#N/A
Standard Deviation	33.96	213.79	28.82	209.37
Sample Variance	1153.50	45706.78	830.83	43834.31
Kurtosis	2.80	-2.19	11.00	-1.87
Skewness	1.70	0.02	3.32	0.11
Range	107.61	462.60	95.74	551.23
Minimum	12.23	0.00	0.00	24.76
Maximum	119.84	462.60	95.74	575.99
Sum	401.67	2452.98	97.27	2951.92
Count	11.00	11.00	11.00	11.00
Confidence Level (95.0%)	22.82	143.63	19.36	140.65

The mesozooplankton biomass showed an increase up to levels of 120 mg.m-3 in north direction (Fig. 12.1); the amount of Noctiluca scintillans increased to 460 mg.m-3 mostly along the Cape Emine - Maslen nos (Fig. 12.2), and the species Pleurobrachia pileus was concentrated in front of Kiten - Cape Maslen nos (Fig. 12.3).

Проектно предложение № BG14MFOP001-3.003-0001, „Събиране, управление и използване на данни за целите на научния анализ и изпълнението на Общата политика в областта на рибарството за периода 2017-2019 г.", финансирано от Програмата за морско дело и рибарство, съфинансирана от Европейския съюз чрез Европейския фонд за морско дело и рибарство.



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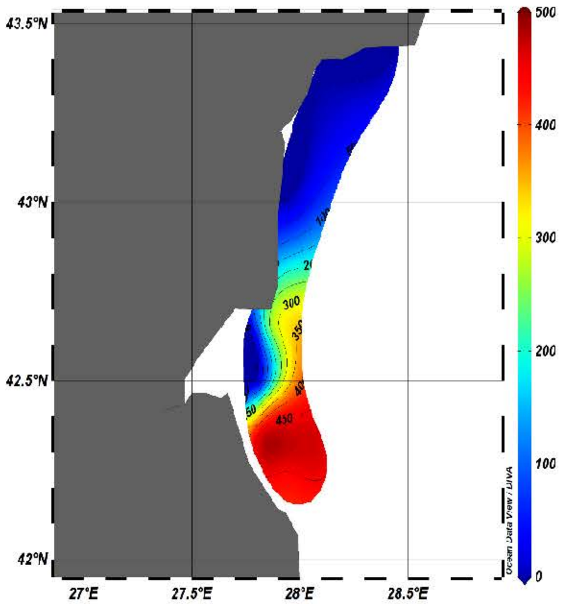

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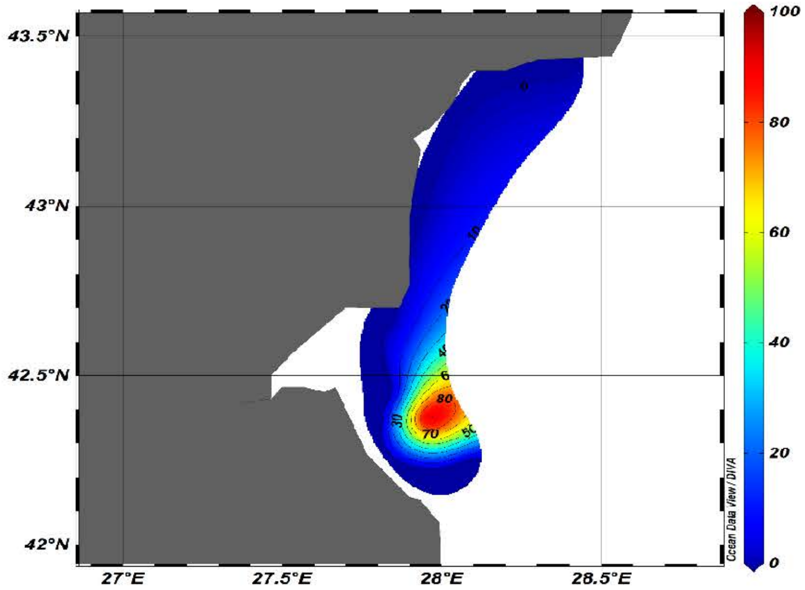

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Figure 5.12. Spatial distribution of biomass (mg.m-3) of mesozooplankton (1), Noctiluca scintillans (2) and Jellyfish (3) in VI.2019.

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6. Forecasts and Operational Opportunities

Steady state of sprat stock

Equilibrium and the associated biomass of sprat from Bulgarian Black Sea waters are presented graphically in Fig.6.1.1. On the first graph, Equilibrium Yield with confidence intervals (showing very low Cimed and CI2.5%), Y / R with CI97.5% reaches its maximum and corresponds to fishing mortality at about 1.16 then follows the plateau the curve follows and the determination of Fmax becomes impossible.

Obviously, levels above F = 0.8 will result in stock collapse. Sustained fishing mortality rates are around F = 0.5, which will correspond to the level of the catch of 12.5 thousand tons of sprat in NW Black Sea

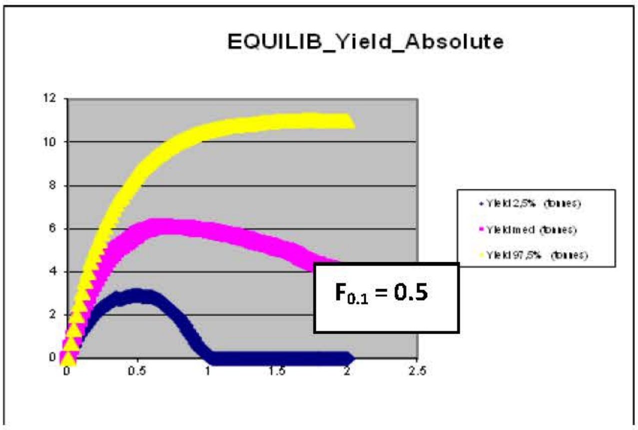

Figure 6.1.1. Equilibrium level with CI. Optimal level of fishing mortality and corresponding catches of sprat from Bulgarian waters.

Biomass of the reproductive stock, vulnerable to fishing biomass and total biomass follow a similar downward trend since only CI values of 97.5% have relatively high levels of the lowest fishing mortality. Therefore, with increasing fishing mortality of all biomass tested (Fig.6.1.2, Fig 6.1.3, and Fig.6.1.4.), A decreasing trend follows, following F = 0.8 (at CI2.5%) and after 1.16 (with Cimed), the stocks of trinkant will

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fall below unsustainable levels - Fig.6.1.1.

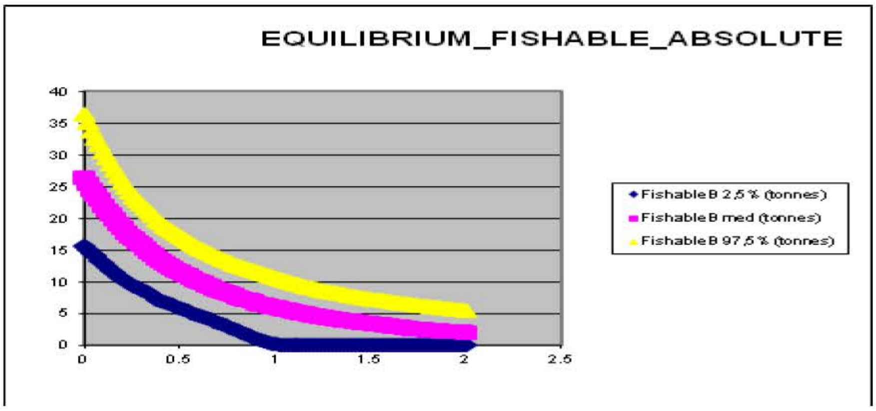

Figure 6.1.2. Balance state of biomass vulnerable to fishing

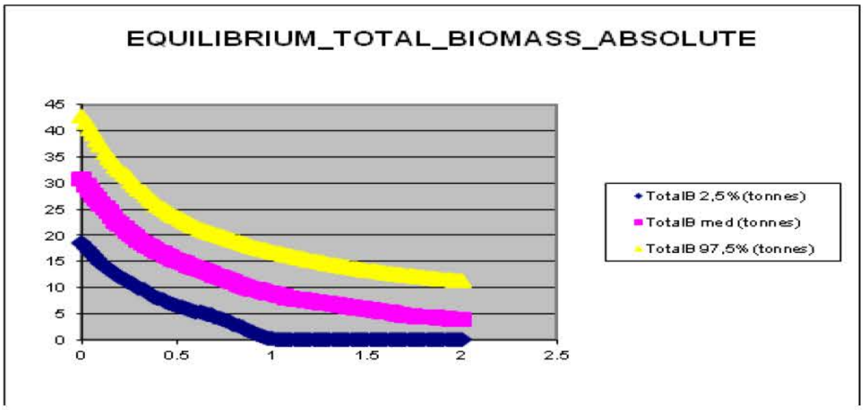

Figure 6.1.3. Balanced state of total biomass

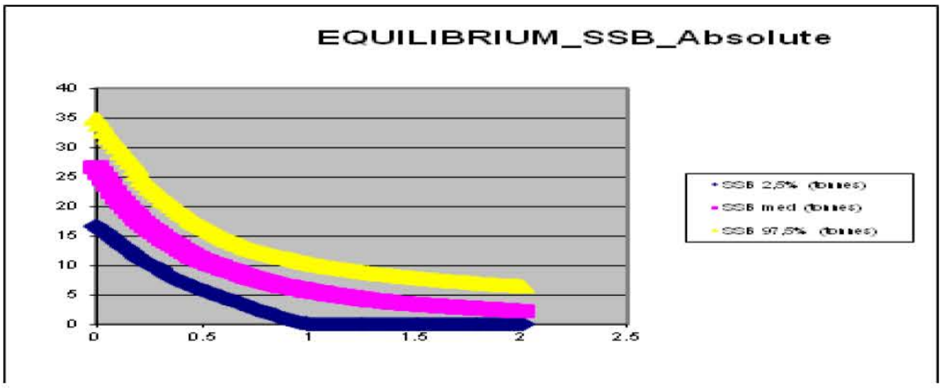

Figure 6.1.4. Sustainable propagation biomass

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Filling is heavily affected by fishing mortality and after F = 0.5 falls very steeply - Fig. 6.1.5.

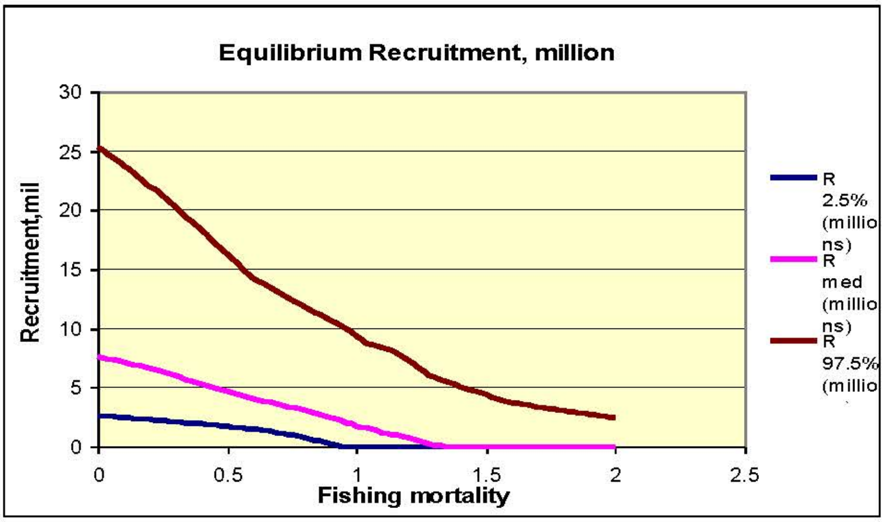

Figure 6.1.5. Balance equilibrium

From Figure 6.1.6. it is clear that the number of individuals in the catch in December marks a peak for 3-3+ year olds.

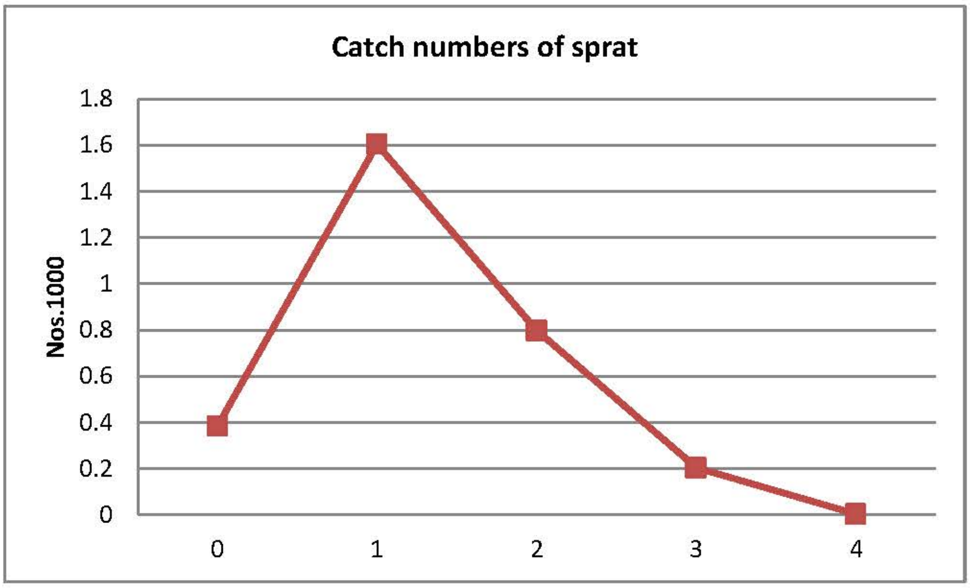

Figure 6.1.6. Catch numbers June 2019 by age for sprat.

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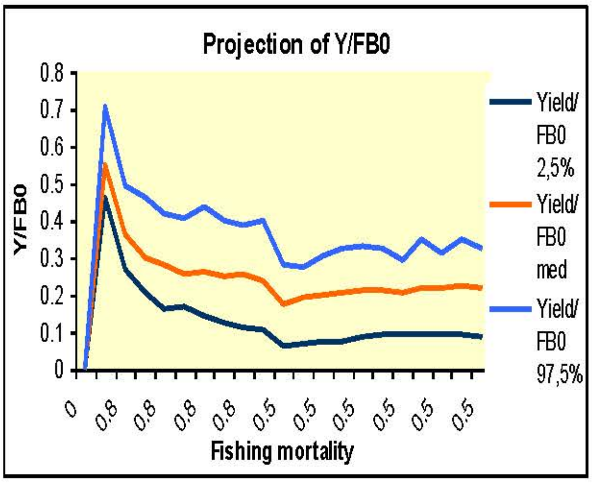
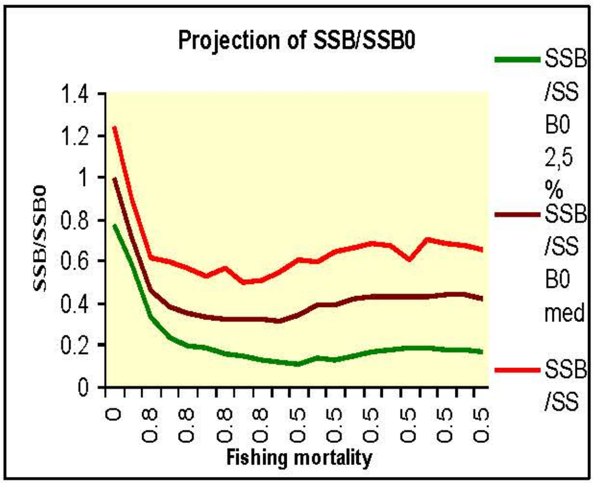
Estimated model of stock parameters related to variation in fishing mortality over 10 years



A)



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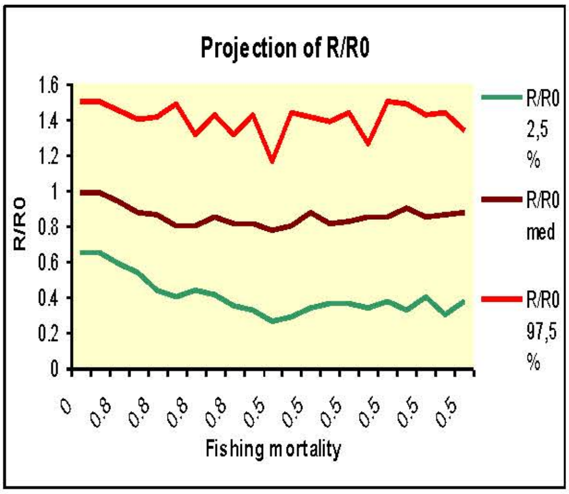
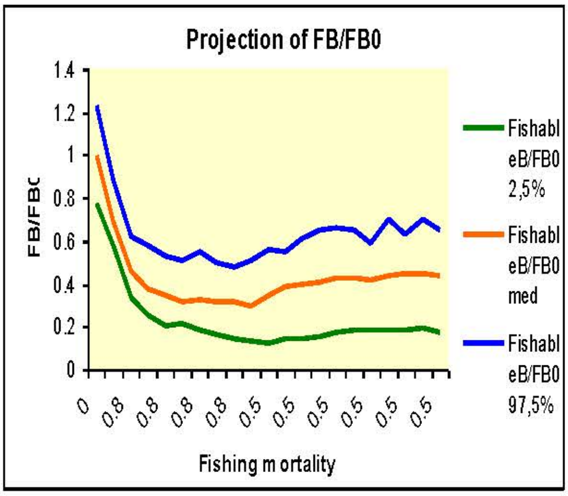


C)



D)

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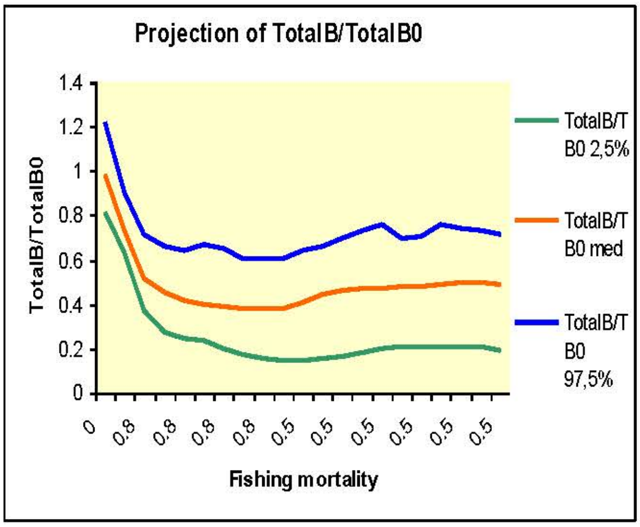

E)

Figure 6.1.6. Forecasts of the stock of turkey stocks related to fishing mortality

Devastated (unexploited)

Relative catches (Y / F0) at very low fishing mortality rates are high during the first forecast year (Fig.7.1 A). At F = 0.8, in the second year, the relative catch is expected to fall to levels of F = 0.5 (Figure 6.1, A). After the fifth year it is expected that the Y / F0 connection plate will be observed at all tested confidence intervals. Similar to SSB / SSB0 (Figure 6.1, B), and even a slight increase of CI 97.5% and SSB / SSB0 honey after a change in fishing mortality (from F = 0.8 to F = 0.5). Filling (Figure 6.1, C) is stable and is not affected by changes in fishing mortality. Biomass Vulnerable by fishing and total biomass presented as a link with biomass when unused state, show similar trends with those of the relative SSB (Figure 6.1, D, E).

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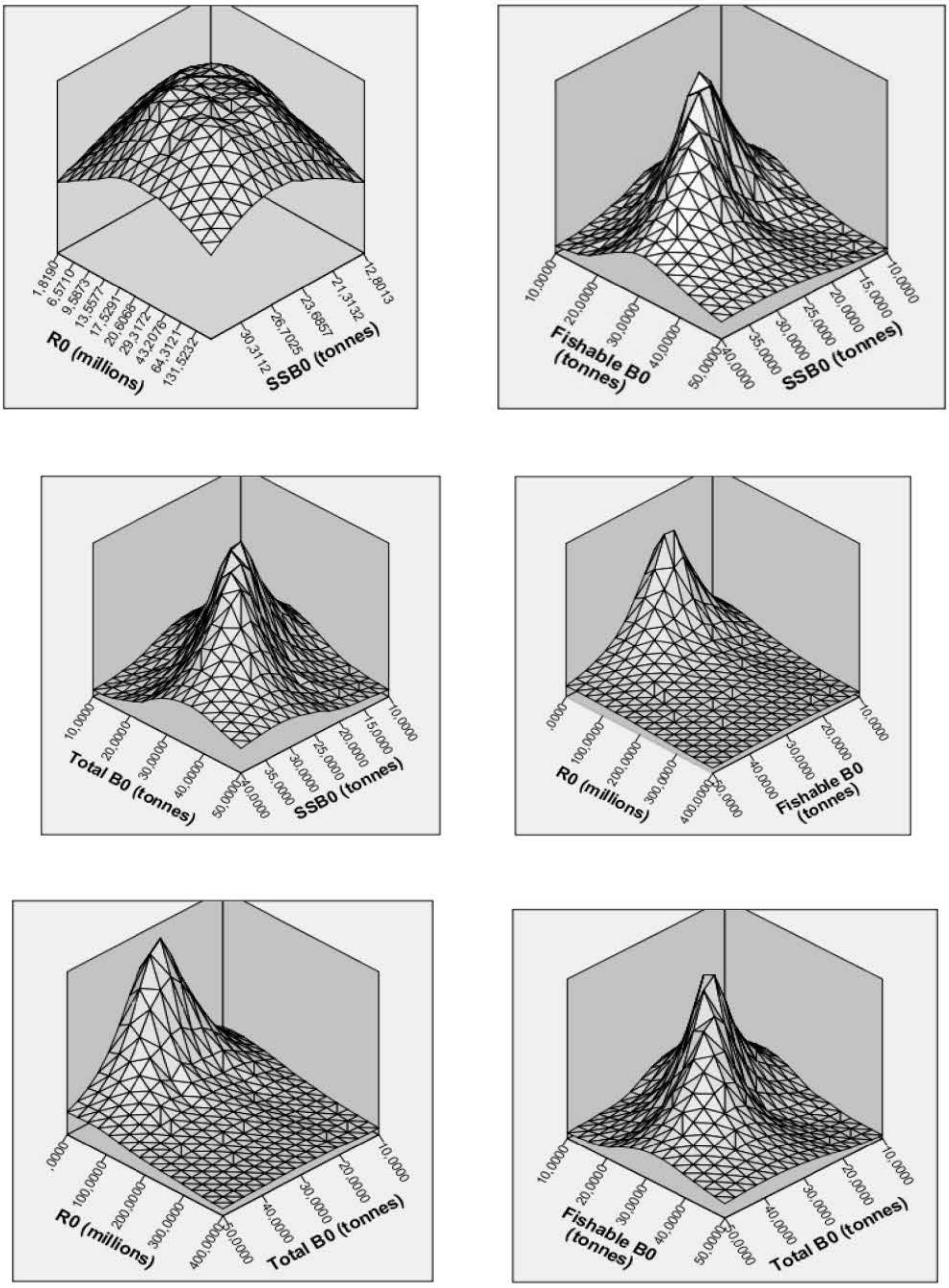

Figure 6.1.7. Unused state

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7. Maximum sustainable yield

Maximum sustainable yield (MSY), according to the Gulland method (1970), is calculated for the exploitation biomass of the studied aquatory. In the present study, we used the mortality mortality coefficient M = 0.95 (Ivanov and Beverton, 1985; Prodanov and al, 1997). The results obtained are given in Table.7.1.

Table.7.1. Biomass (t) and MSY.

Bulgaria	Biomass (t)	MSY (t)	
		Gulland	BH steepness, $F_{0.1}$
JUNE	25 903,47	12 952 t	12 500 t

Expected MSYs are the maximum potential catches, including quota-based catch, as well as false or unreported catches and by-catches in other fisheries. Calculated exploitation biomass and equilibrium levels (MSYs) should not be considered as an absolute value for possible future yields given the fact that the methods have some ambiguities and the share of IUU catches is still unknown. In such cases, special approaches have been used, such as 2/3 MSY (Caddy and Mahon, 1995).

The recommended value of the catches in the Bulgarian Black Sea Basin, according to the current condition, should not exceed 8600 tonnes.

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8. Conclusions

1. The total number of identified species is 24, of which 16 fish (with 2 species more than the autumn survey in 2018), 2 crustaceans, 2 molluscs and 4 macrozooplankton species. The most common species in generally trawl operations (in terms of presence / absence) are (in descending order): in June 2019: *S. sprattus* (76.5%) *M. barbatus* (9.66%), and *M. merlangius* (4.86%) other species such as *A. immaculata, N. melanostomus, G.niger,* etc. have a negligible presence in the catch in June 2019.

2. Sprat (*Sprattus sprattus*) The species had the highest recorded biomass and catch per unit area in the study areas in June 2019. At stratum 15-30m CPUA = 1867.7 kg.km^{-2} and 12 497 t.

3. In June 2019, the baboon was the least represented in the shallow coastal zone 15-30m with a CPUA = 52.9 kg.km^{-2} and a biomass of 109.25 t. The highest CPUA values of 419 kg.km^{-2} were established in the 30-50m depth lane with biomass of 761 t.

4. In June 2019, the whiting was most strongly represented in the shallow coastal zone 15-30m with CPUA = 270 kg.km^{-2} and biomass of 557 t., Followed by a depth strip of 30-50m with a catch per unit area of 218 kg .km^{-2} biomass 396 t, 115 kg.km-^{2} for CPUA and 473 t biomass at depths of 50-100m.

5. The total biomass in June 2019 is 25 903.47 tonnes for the Bulgarian Black Sea area;

6. The total study area in the Bulgarian part is 8010.24 km.kg^{-2} and the total identified biomass of the bubbler is 1837.4 tonnes in June 2019;

7. The total area surveyed was 8010.24 km$^{-2.}$ The total biomass of whiting in June 2019 is 1426.5 tonnes in the Bulgarian Black Sea area.

8. Sprat size frequencies indicate maxima in the distribution of classes (7.5-8 cm), of whiting, with a pronounced bimodal distribution with peaks of 8-10 and 11-13 cm; peaks were observed at 11-12 and 14 cm.

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9. The prevalence of sprat in this study is 1-1 + (74%);

10. The prevailing age for whiting in this study was 2-2 +

11. The predominant age of the red mullet was 2-2 + (27%), followed by ages 1-1 + (24.7%), 3-3 + (20.5%), Senior age and juvenile forms were present with a low percentage.

12. Sprat was not active in the spawning phase of this investigation in June. Most of the individuals have stage I-II, III glands. A more detailed analysis should be made in the active spawning period of the species (October-February).

13. GSI (%) indicates that a small percentage of females are actively breeding. Most individuals were in the early stages of maturation, so we can conclude that in June 2019, active reproduction did not begin.

14. In June 2019, the sprat food spectrum was constituted by 19 zooplankton species/groups, including several copepods - Calanus euxinus, Pseudocalanus elongatus, Paracalanus parvus, Acartia clausi, Centropages ponticus, Oithona spp., Harpactiocoida spp., Copepoda spp; five taxonomic groups meroplankton - Lamellibranchia veliger, Gastropoda veliger, Cirripedia larvae, Decapoda larvae, Polychaeta larvae; class Chaetognatha was presented by Parasagitta setosa, class Appendicularia - from Oicopleura dioica. Single specimens Noctiluca scintillans and Pisces ova were also found in the sprat ration.

15. The average ISF attained 0.80% BW ± 0.53 (SD), with an increase of 40.60% over the average value for 2007-2010 (0.53 % BW). High mean levels of ISF = 1.4% BW were registered in front of Ahtopol and below the Cape Kalikara, while minimal levels (~ 0.5% BW) were established in the shallow coastal zone between Varna and Sozopol Bays.

16. The mean PN attained 205.35 ind/stomach ± 260.39, as the highest average PN - 621 and/stomach was found in north direction, below the Cape Kalikara (16 m depth), connected with the excessive consumption of Acartia clausi. A high average PN of 554 ind/stomach was established in front of the Cape Maslen nos, (41 m

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depth), related to the consumption of Lamellibranchia veliger.

17. During the survey, the total zooplankton biomass attained 268.36 mg.m-3 ± 63.13 (SE), while the protozoan N. scintillans biomass was 223 mg.m-3 ± 64.46 (SE), the fodder mesozooplankton formed quantities of 36.52 mg.m-3 ± 10.24 (SE), and the jellyfish biomass was 8.84 mg.m-3 ± 8.69 (SE). The total biomasses of fodder zooplankton and jellyfish species were estimated as relatively low for the season.

18. Increase in the fodder mesozooplankton biomass up to 120 mg.m-3 was established in the northern sector, and an increase in the amount of Noctiluca scintillans to 460 mg.m-3 was recorded in the Emine – Maslen nos zone, while the species Pleurobrachia pileus was concentrated in front of Kiten - Maslen nos. The northern shores represent relatively good conditions for sprat feeding, and a particular increase in the nutritional indices of sprat was also found in the Ahtopol - Cape Maslen nos zone.

19. The increase of the biomass of the food mesozooplankton in the northern coasts has been established - up to 120 mg.m-3; and an increase in the amount of Noctiluca scintillans to 460 mg.m-3 was recorded in the Emine - Oil Cape strip, while the Pleurobrachia pileus species was concentrated in front of the Kiten - Oil Cape. The northern shores have relatively good conditions for feeding the Tricone, and a certain increase in the nutritional indices of the Tricone is also found in the Ahtopol - Maslen Cape zone.

20. The maximum sustainable yield (MSY), in accordance with the Gulland method (1970), is estimated at 12 952 t; BH steepness, F0.1 = 12,500 t.

21. The calculated exploitation biomass and equilibrium levels (MSYs) should not be considered as an absolute value for possible future yields, given the fact that the methods have some uncertainties and the proportion of IUU catches is still unknown. In such cases, special approaches such as using 2/3 MSY were used (Caddy and Mahon, 1995).

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22. The recommended value of catches in the Bulgarian Black Sea waters, according to the current situation, should not exceed 8600 tonnes.

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ANNEX I CPUE kg.h-1 and CPUAkg.km-2 in the Bulgarian part of the Black Sea - sprat, whiting and red mullet

CPUEkg/h	CPUAkg/k
1636,364	19042,36
818,1818	9521,182
227,2727	2644,773
909,0909	10579,09
1363,636	15868,64
909,0909	10579,09
1363,636	15868,64
1363,636	15868,64
1818,182	21158,18
681,8182	7934,318
1090,909	12694,91
454,5455	5289,545
681,8182	7934,318
545,4545	6347,455
590,9091	6876,409
227,2727	2644,773
681,8182	7934,318
909,0909	10579,09
636,3636	7405,364
727,2727	8463,273
409,0909	4760,591
500	5818,5
636,3636	7405,364
818,1818	9521,182
150	1745,55
181,8182	2115,818
909,0909	10579,09
636,3636	7405,364
636,3636	7405,364
363,6364	4231,636
409,0909	4760,591
909,0909	10579,09
454,5455	5289,545
0	0
227,2727	2644,773
136,3636	1586,864
0	0

а)

CPUEkg/h	CPUAkg/k
9,090909	105,7909
13,63636	158,6864
22,72727	264,4773
68,18182	793,4318
0	0
0	0
2,272727	26,44773
0	0
45,45455	528,9545
4,545455	52,89545
4,545455	52,89545
9,090909	105,7909
4,545455	52,89545
22,72727	264,4773
22,72727	264,4773
22,72727	264,4773
13,63636	158,6864
13,63636	158,6864
22,72727	264,4773
22,72727	264,4773
45,45455	528,9545
0	0
0	0
0	0
0	0
0	0
0	0
9,090909	105,7909
22,72727	264,4773
13,63636	158,6864
13,63636	158,6864
4,545455	52,89545
22,72727	264,4773
4,545455	52,89545
9,090909	105,7909
4,545455	52,89545
0	0

б)

CPUEkg/h	CPUAkg/k
4,545455	52,89545
4,545455	52,89545
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
0	0
9,090909	105,7909
9,090909	105,7909
22,72727	264,4773
22,72727	264,4773
4,545455	52,89545
4,545455	52,89545
4,545455	52,89545
4,545455	52,89545
45,45455	528,9545
90,90909	1057,909
90,90909	1057,909
68,18182	793,4318
90,90909	1057,909
90,90909	1057,909
4,545455	52,89545
13,63636	158,6864
4,545455	52,89545
4,545455	52,89545
13,63636	158,6864
9,090909	105,7909

в)

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ANNEX II Species composition in the Bulgarian

		Start		End						
Date	Trawls	N	E	N	E	Description of trawls	№, plankton	№, stomach	depth, m	№, DNA
08.06.2019	1	42.458388	27.829595	42.449619	27.858528	*360 kg S.sprattus, 15 бр. M.merlangus, 1 бр. M.barbatus*	2	1	37	
08.06.2019	2	42.389953	27.924186	42.371801	27.945546	*180 kg S.sprattus, 20 бр. M.merlangus, 1 бр. M. barbatus*	3	4	39	
08.06.2019	3	42.313893	28.104401	42.318671	28.142564	*10 kg A.aurita*			67-75	
08.06.2019	4	42.265748	28.171686	42.261012	28.130405	*200 kg S.sprattus, 5 kg M.merlangus, 3 kg A.aurita*			81	
08.06.2019	5	42.254808	28.111101	42.252977	28.081764	*300 kg S.sprattus, 15 kg M.merlangus, 5 kg A.aurita, D.delphis - 20 бр.*	5	6	60	5-S.maximus
09.06.2019	6	42.418577	27.795370	42.391944	27.806546	*200 kg S.sprattus*			38	
09.06.2019	7	42.385003	27.808578	42.358501	27.818090	*300 kg S.sprattus*	7	9	42	
09.06.2019	8	42.338717	27.814046	42.300659	27.835064	*300 kg S.sprattus, 5 бр. M.merlangus*			50-52	
09.06.2019	9	42.254321	27.895999	42.231004	27.930733	*400 kg S.sprattus, D.delphis - 15 бр.*	8	10	41	
09.06.2019	10	42.291884	28.006395	42.319416	27.977566	*150 kg S.sprattus, 10 kg M.merlangus, 1 бр. P.flesus*			51-49	11-P.flesus
09.06.2019	11	42.375979	27.942515	42.389112	27.915019	*240 kg S.sprattus*			41-39	
11.06.2019	12	42.434899	27.770478	42.463454	27.799338	*100 kg S.sprattus, 10 kg A.aurita*			35	
11.06.2019	13	42.468698	27.804672	42.489822	27.825500	*150 kg S.sprattus, 15 kg A.aurita, D.delphis - 15 бр.*	11	`12	36	
11.06.2019	14	42.473905	27.886203	42.455591	27.856802	*120 kg S.sprattus, 5 бр. M.merlangus, 4 бр. Gobiidae, D.delphis - 15 бр.*			37	
11.06.2019	15	42.452590	27.851214	42.439847	27.831276	*130 kg S.sprattus, 7 бр. M.merlangus, 6 бр. Gobiidae, D.delphis - 15 бр.*			36	
12.06.2019	16	42.545857	27.864756	42.571139	27.841242	*20 kg A.aurita*			37	
12.06.2019	17	42.585774	27.854196	42.611589	27.843443	*150 kg S.sprattus, 15 бр. M.merlangus, 10 бр. M. barbatus, 10 kg A.aurita*			32	
12.06.2019	18	42.619065	27.844205	42.648905	27.855974	*200 kg S.sprattus, 15 бр. M.merlangus, 10 бр. M. barbatus, 10 kg A.aurita*	14	13	27	
12.06.2019	19	42.688405	27.844863	42.692831	27.808492	*140 kg S.sprattus, 5 kg M.merlangus, 5 kg M.barbatus*			20	
12.06.2019	20	42.692831	27.801253	42.689479	27.754313	*160 kg S.sprattus, 5 kg M.merlangus, 5 kg M.barbatus, A.stellatus, P.flesus, S.maximus, D.delphis-4 бр.*			19	18, 19, 20
13.06.2019	21	42.680526	27.780544	42.652097	27.790041	*90 kg S.sprattus, 3 kg M.merlangus, 1 kg M.barbatus*			23	

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ANNEX III. Surveys indicator targets and results in 2019 June (Bulgarian part)

Black Sea	Length @age	market, discards, surveys	2,50%	Survey: **2565** 1250
Black Sea	Weight @length	market, discards, surveys	2,50%	Survey: **2565** 5000
Black Sea	Weight @age	market, discards, surveys	2,50%	Market: Discard: - Survey: **2565** 1250
Black Sea	Maturity @length	surveys	2,50%	5000 **140**
Black Sea	Maturity @age	surveys	2,50%	5000 **140**
Black Sea	Sex-ratio @length	market, surveys	2,50%	Market: **250** Survey: **250** 125
Black Sea	Sex-ratio @age	market, surveys	2,50%	Market: Survey: **250** **250**

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Navigation, bathymetry and hydroacoustics

For more sensitivity interpretation of the results of trawl picture was used navigation software OpenCPN 4.8.0 [1] and GPS “HOLLUX” (fig. 1, 2)

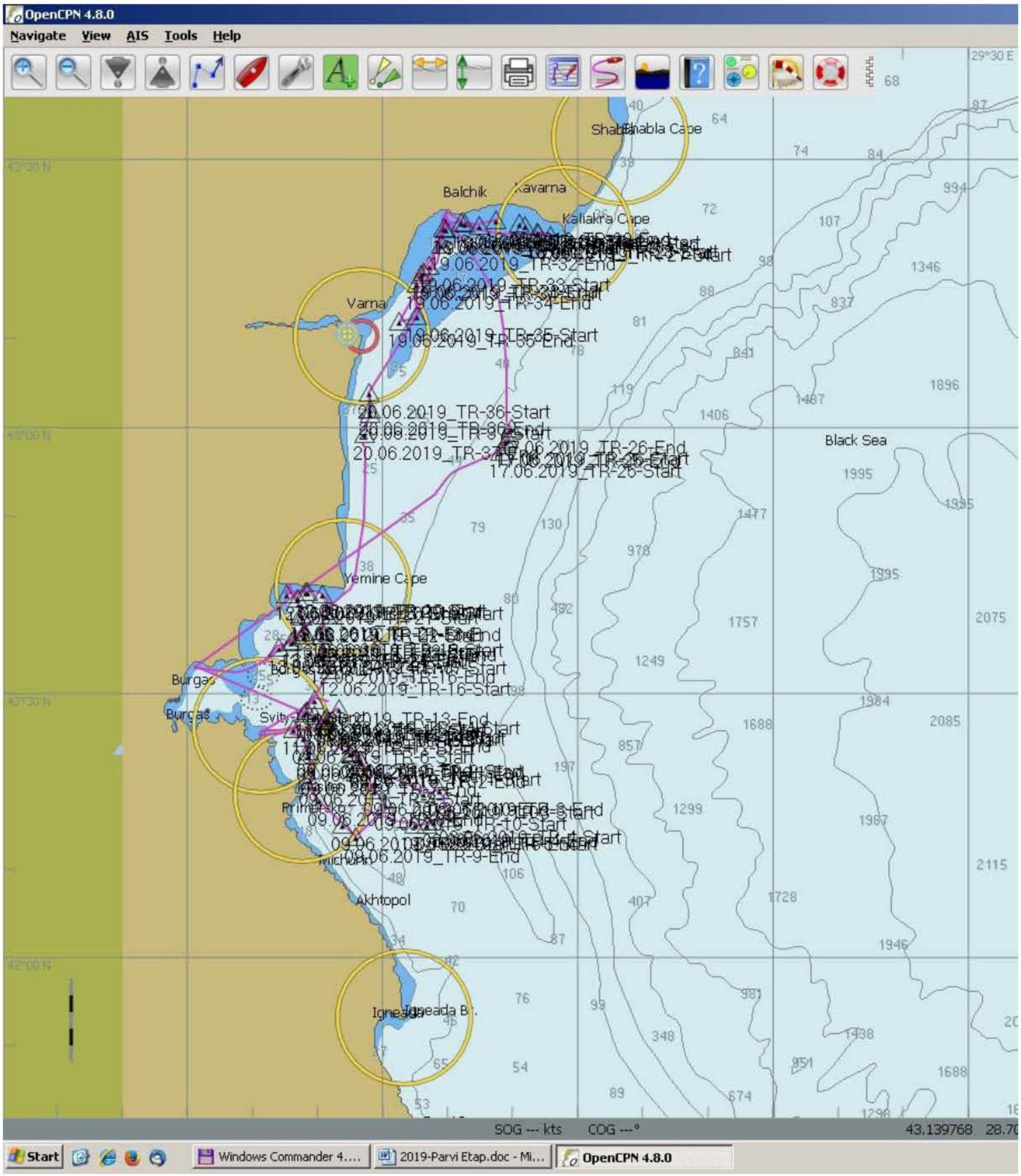

Figure1. Navigation map of the expedition in June 2019 (OpenCPN 4.8.0) [1]

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For more detailed depth measurement, determination of the fish species and determination of the bottom sediments type, was used Hydrographic Survey Echo Sounder “LituGraph 4F” **(fig. 2 - 5).**

Figure 2. Hydrographic Survey Echo Sounder “LituGraph 4F”.

Trawl 27, fish schools of S.sprattus

Figure 3. Trawl 27, catch - 150 kg S.sprattus, 5 kg E.encrasicolus, 10 kg M.merlangus, 10 kg M.barbatus, 2 ind. A.immaculata, 20 kg Gobiidae, 5 kg A.aurita,5 ind. T. Mediterraneus, 3 ind. A.stellatus, 3 ind. S.maximus.

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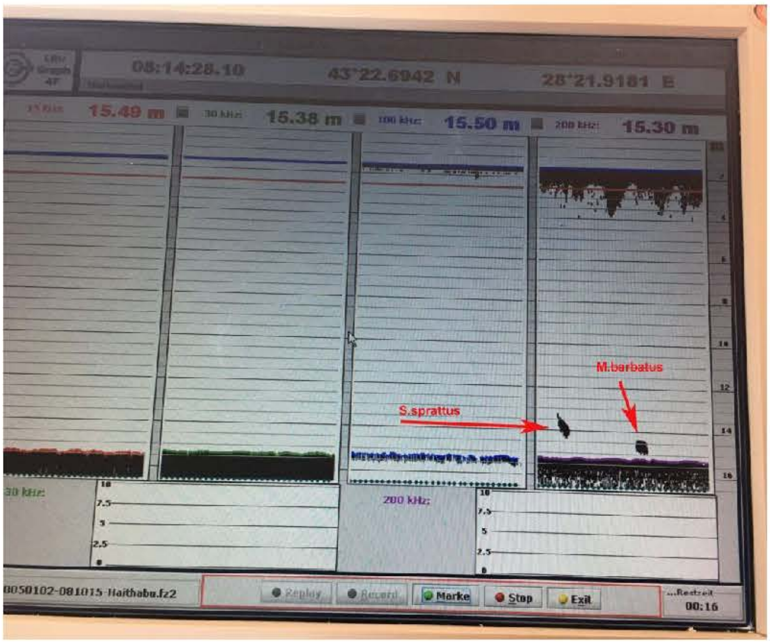

Figure 2. Hydrographic Survey Echo Sounder "LituGraph 4F".

Trawl 31, **fish schools of** S.sprattus, M.barbatus, Gobiidae.

Figure 3. Trawl 31, catch - 90 kg S.sprattus, 20 kg M.barbatus, 3 ind. A.immaculata, 20 kg Gobiidae, 70 kg A.aurita, 7 бр. T. Mediterraneus, 2 ind. S.maximus,1 ind. U.scaber, 5 ind. E.encrasicolus

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For the purposes and tasks of the present study, the hydro-acoustic equipment SIMRAD - NSO evo3 / HDS Carbon / LOWRANCE (Fig. 6, 7, 8), [2, 3] was used.

Figure 4. SIMRAD - NSO evo3 / HDS Carbon / LOWRANCE

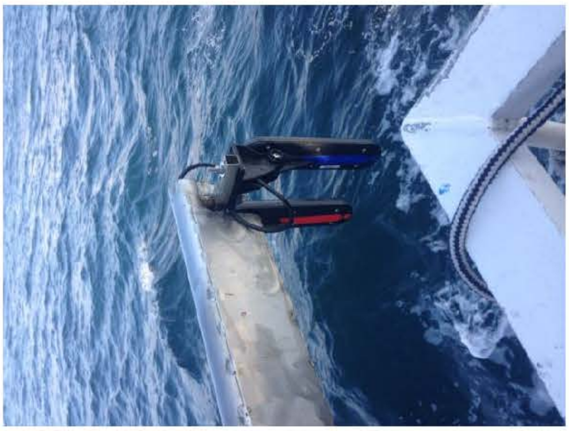

Figure 5. Probe of "SIMRAD - NSO evo3"

The hydroacoustic profiles make it possible to determine the quantitative and qualitative characteristics of the fish schools in combination with the macroscopic description of the trawl picture taken.

NSO evo3 delivers the ultimate view with an ultra-bright display, available in 16, 19, or 24-inch widescreen sizes. Wide viewing angles keep the screen in view from anywhere in sight, even if you're wearing polarized sunglasses. See more

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than ever with Full HD resolution, and the option to combine up to six panels in a split-screen layout. Intuitively navigate charts, define waypoints, and take control of connected systems such as autopilot, radar, and sonar with a touch.

The Carbon HDS Series combines side imaging, downscan imaging, dual-channel CHIRP sonar, real-time underwater 3D mapping capabilities and ultra-bright displays to deliver the most advanced and easy-to-use fish finder/chart plotter on the market. The units' touch-screen interface works much like a smartphone with pinch-to-zoom and touch-and-move abilities for fast and intuitive control.

HDS Carbon units also feature the ability to create custom maps using recorded sonar logs. Anglers can add custom color layers, vegetation and bottom-hardness overlays. Each unit supports the most advanced marine technology and is easily updated to the most current software for optimal performance.

Featuring a powerful dual-core, high-performance processor, the HDS Carbon delivers accurate and definitive images with superior target separation. HDS Carbon multi-touch, super bright displays offer a wider viewing angle and feature an advanced anti-reflective coating for ultimate viewing in bright sunlight and while wearing polarized sunglasses.

HDS Carbon units remove the hassle of constantly monitoring and repositioning the boat with connectivity to certain autopilot trolling motors and shallow water anchors, freeing up anglers to concentrate on fishing. Both bow-mounted and console sonar can be displayed side-by-side with different zoom levels for a clear and precise view of schools or individual fish.

"SIMRAD - NSO evo3" provides the following data processing capabilities: navigation map, sonar and radar.

The Sonar feature provides an underwater view of the area, under and around the ship, allowing easy visualization of fish passages and geological - geomorphologic exploration of the sea floor. The format of the files is <*.sl3>, which includes the Sonar and StructureScan3D options. StructureScan HD provides a 328-meter wide-screen coverage with SideScan, while DownScan ™ provides a detailed view of the bottom structure and fish passages directly below the boat up to 92 m. StructureScan 3D is a multi-beam sonar technology that allows you to observe the structure and geomorphological features of the bottom in 3D.

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The "ReefMaster2.0.38.0" software was used to process and interpret hydroacoustic profile data (fig. 8) [4].

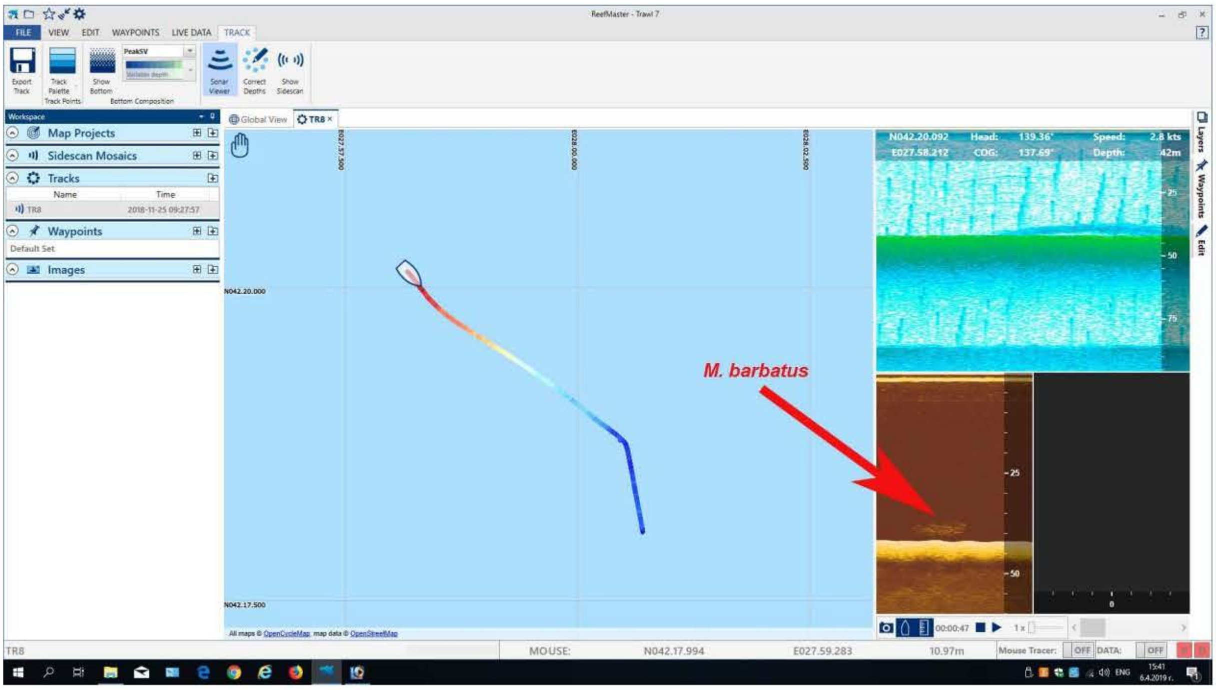

Figure 8. Processing and interpretation of hydroacoustic profile data (ReefMaster2.0.38.0)

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ANNEX III Surveys indicator targets and results ин 2018 (Bulgarian part)

Black Sea	Length @age	market, discards, surveys	2,50%	Survey: 12 427 1250
Black Sea	Weight @length	market, discards, surveys	2,50%	Survey: 12 427 5000
Black Sea	Weight @age	market, discards, surveys	2,50%	Market: 2026 Discard: - Survey: 12 427 1250
Black Sea	Maturity @length	surveys	2,50%	5000 140
Black Sea	Maturity @age	surveys	2,50%	5000

Проектно предложение № BG14MFOP001-3.003-0001, „Събиране, управление и използване на данни за целите на научния анализ и изпълнението на Общата политика в областта на рибарството за периода 2017-2019 г.“, финансирано от Програмата за морско дело и рибарство, съфинансирана от Европейския съюз чрез Европейския фонд за морско дело и рибарство.

				140
Black Sea	Sex-ratio @length	market, surveys	2,50%	Market: 250 Survey: 250 125
Black Sea	Sex-ratio @age	market, surveys	2,50%	Market: 250 250 survey

Проектно предложение № BG14MFOP001-3.003-0001, „Събиране, управление и използване на данни за целите на научния анализ и изпълнението на Общата политика в областта на рибарството за периода 2017-2019 г.“, финансирано от Програмата за морско дело и рибарство, съфинансирана от Европейския съюз чрез Европейския фонд за морско дело и рибарство.

ANNEX IV Navigation, bathymetry and hydroacoustics

For more sensitivity interpretation of the results of trawl picture was used navigation software OpenCPN 4.8.0 [1] and GPS "HOLLUX" (fig. I, II)

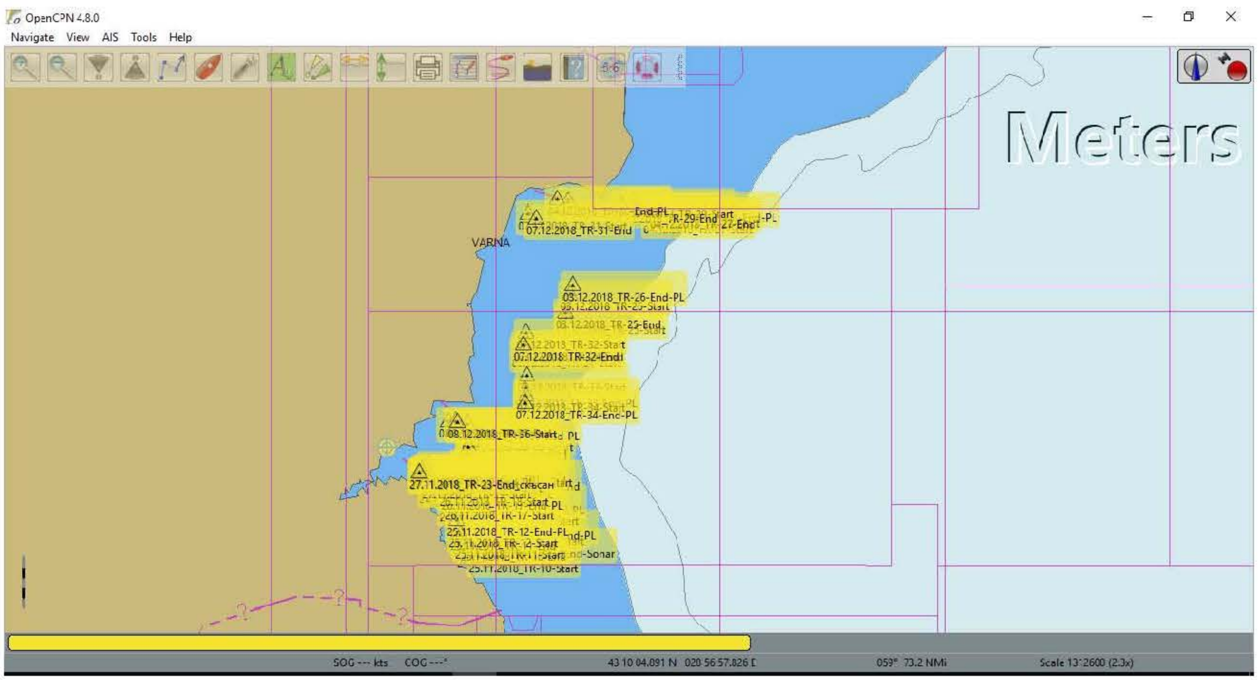
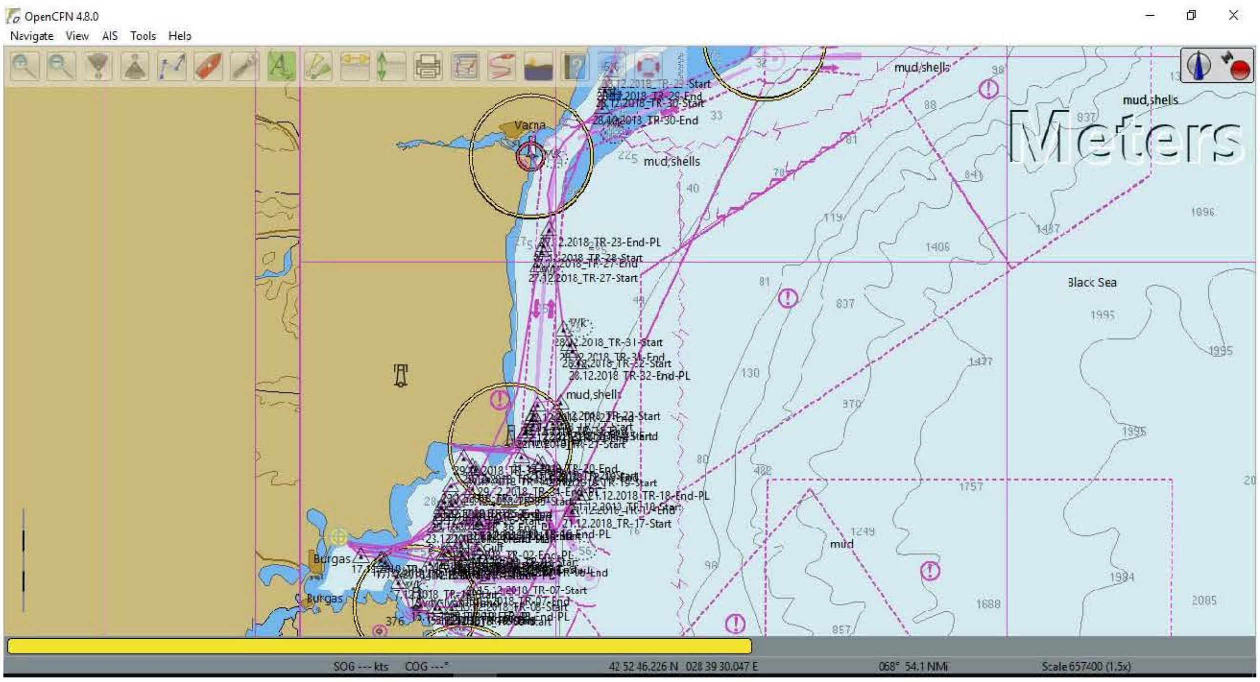


Figure I. Navigation map of the first expedition 2018 (OpenCPN 4.8.0) [1]



Navigation map of the second expedition 2018 (OpenCPN 4.8.0) [1]

For the more detailed depth measurement and determination of the bottom sediments type, was used Hydrographic Survey Echo Sounder "LituGraph 4F" (fig. III)

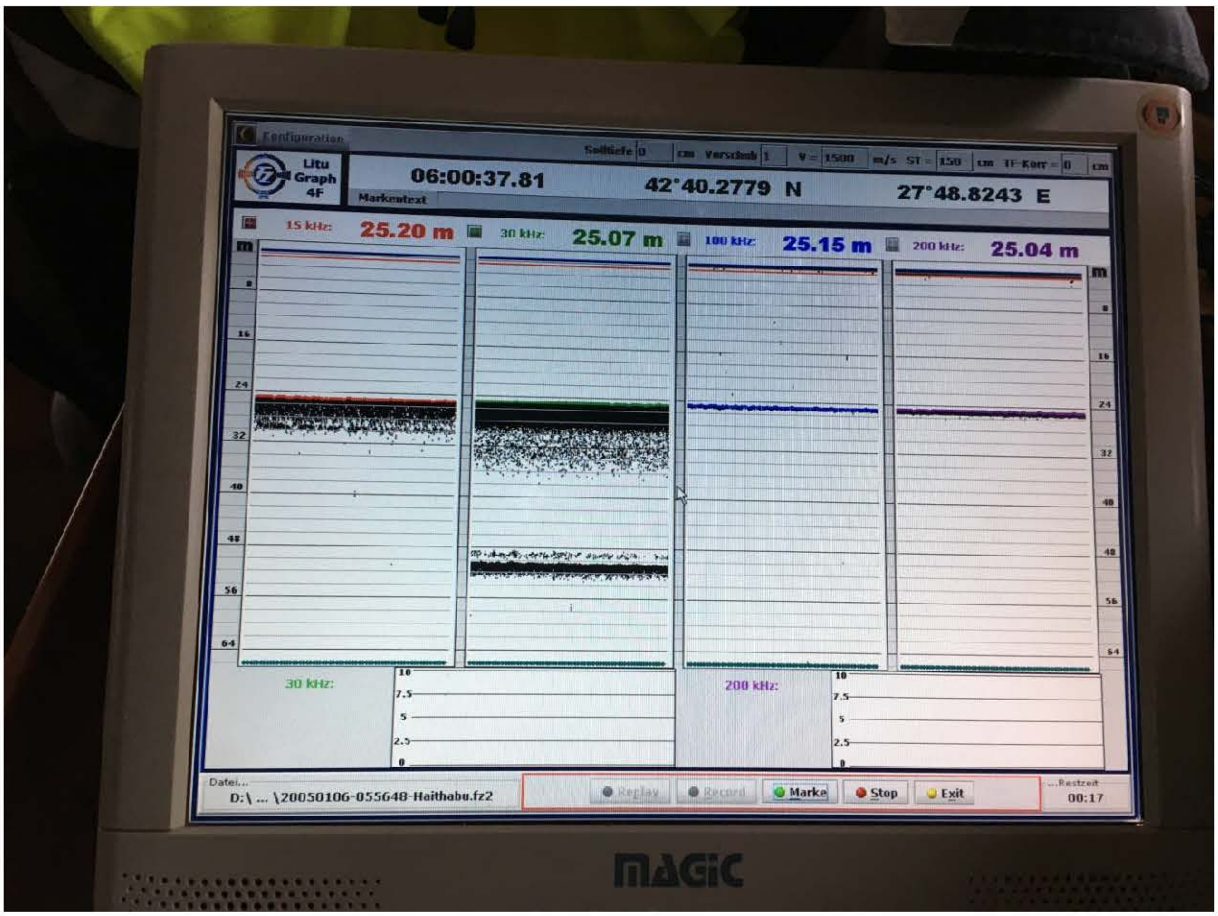


Figure III. Hydrographic Survey Echo Sounder "LituGraph 4F"

For the purposes and tasks of the present study, the hydro-acoustic equipment SIMRAD - NSO evo3 / HDS Carbon / LOWRANCE (Fig. IV, V) was used.

Figure IV. “SIMRAD - NSO evo3”

Figure V. Probe of "SIMRAD - NSO evo3"

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The hydroacoustic profiles make it possible to determine the quantitative and qualitative characteristics of the fish schools in combination with the macroscopic description of the trawl picture taken. Due to the unfavorable autumn-winter weather conditions (strong wind, excitement over 4 balls and low temperatures), 3 profiles were made during the first stage of the expedition. Excitement over 4 bales may cause a sonar probe to break or damage and also is danger for live of crew.

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The "ReefMaster2.0.38.0" software was used to process and interpret hydroacoustic profile data (fig. VI-XI).

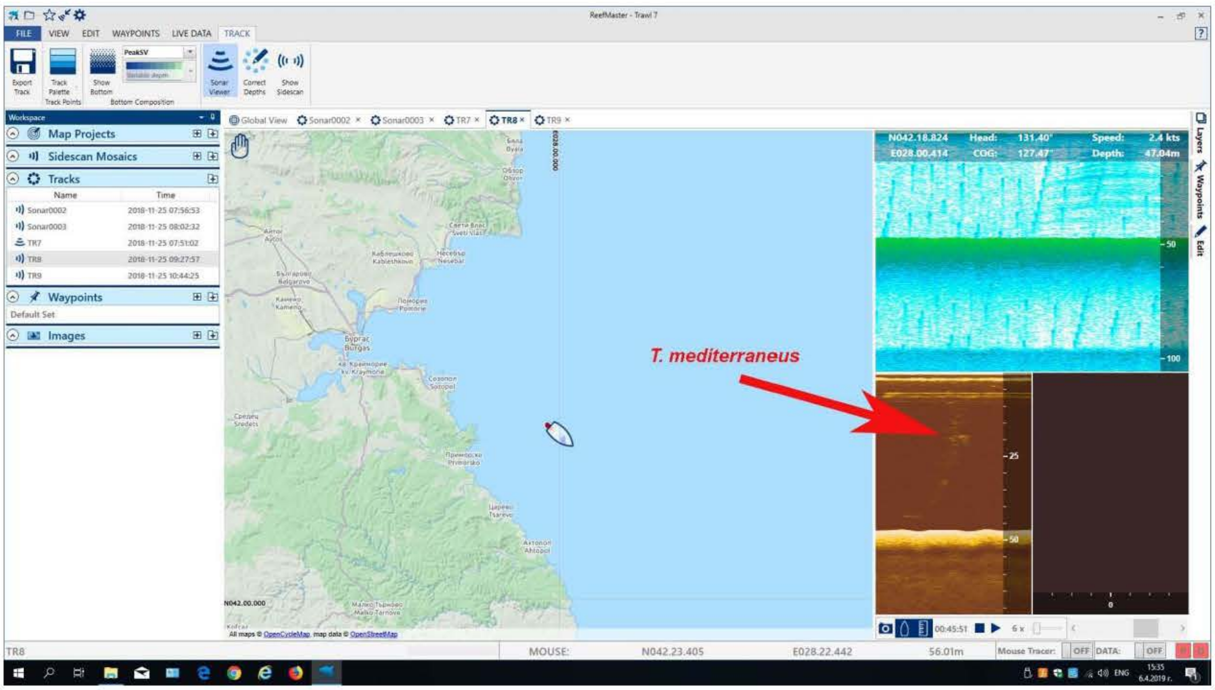

Figure VI. First Stage of survey

1. First Stage

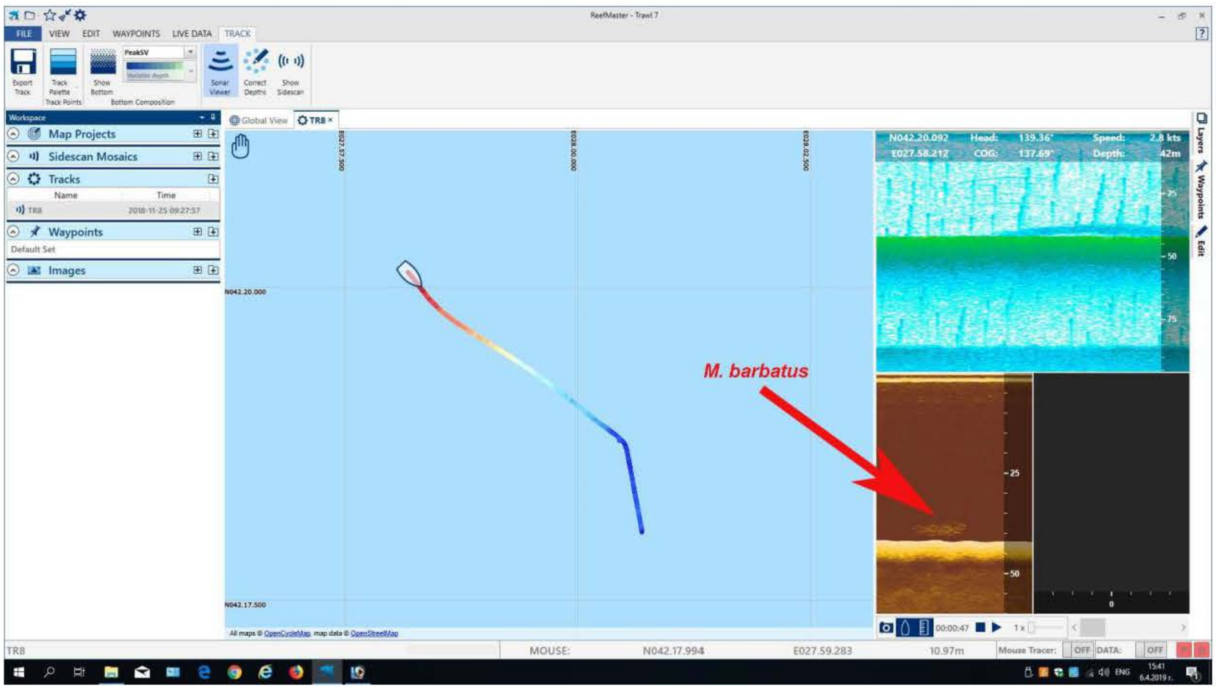

Figure VII. Trawl 8, situation – 1, start, fish cloud of M. barbatus

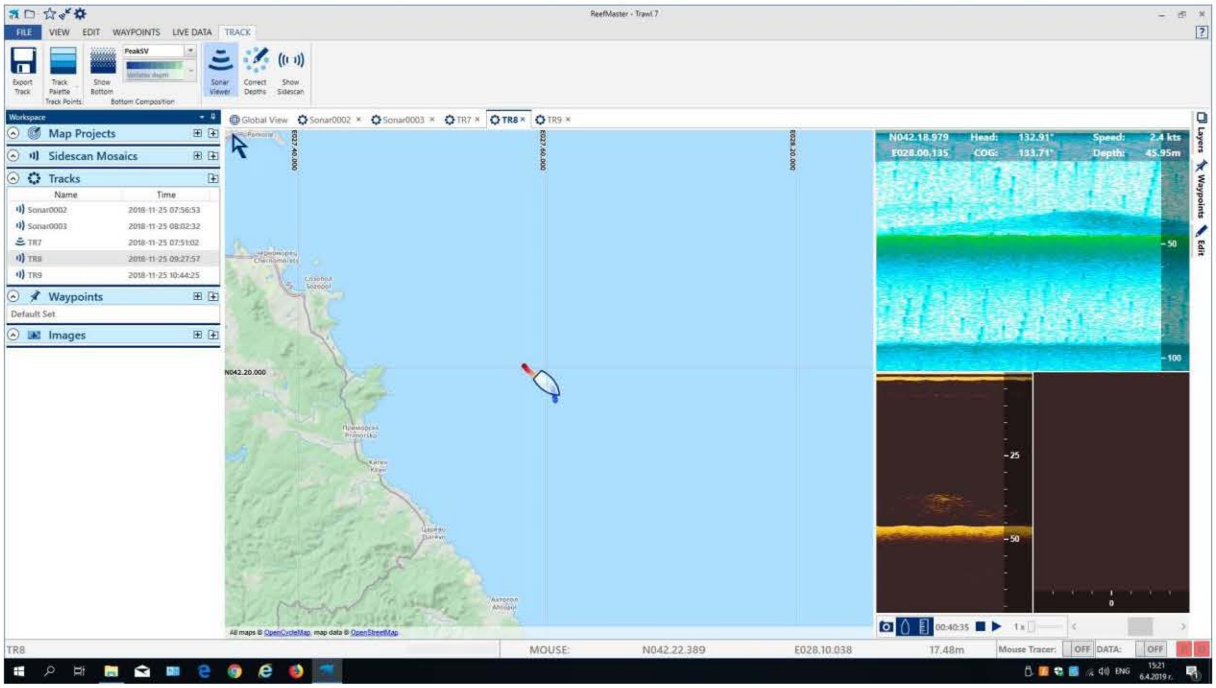

Figure VIII. Trawl 8, situation – 2

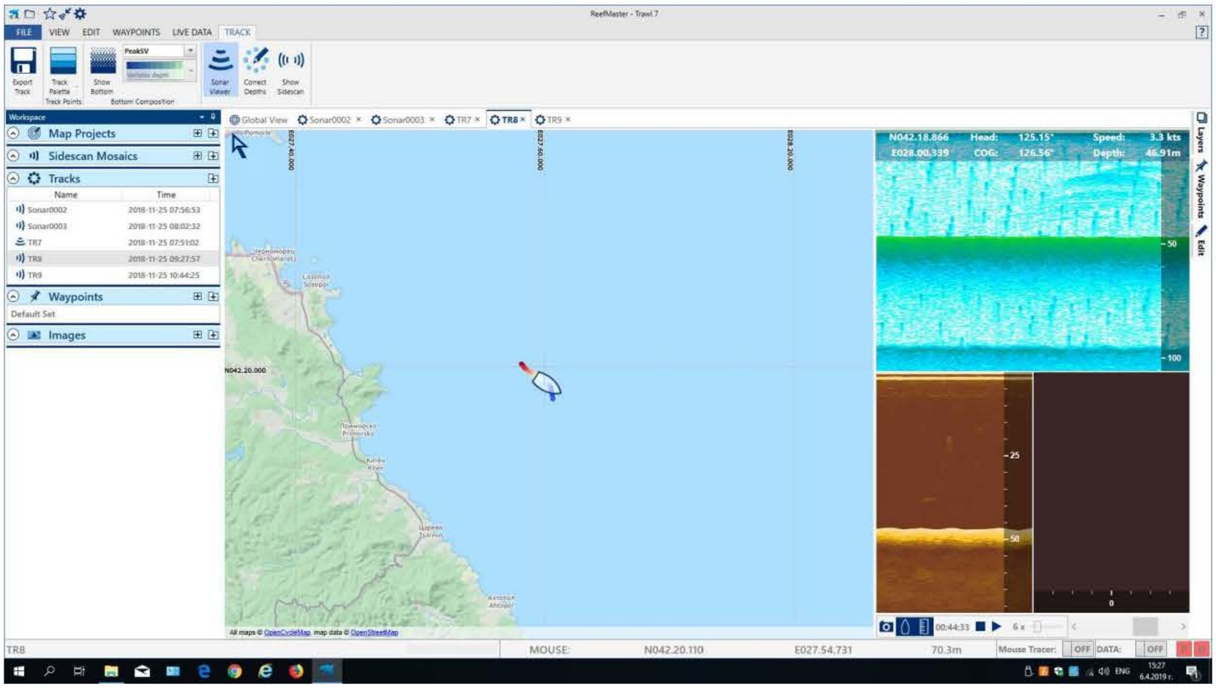

Figure IX. Trawl 8, situation – 3

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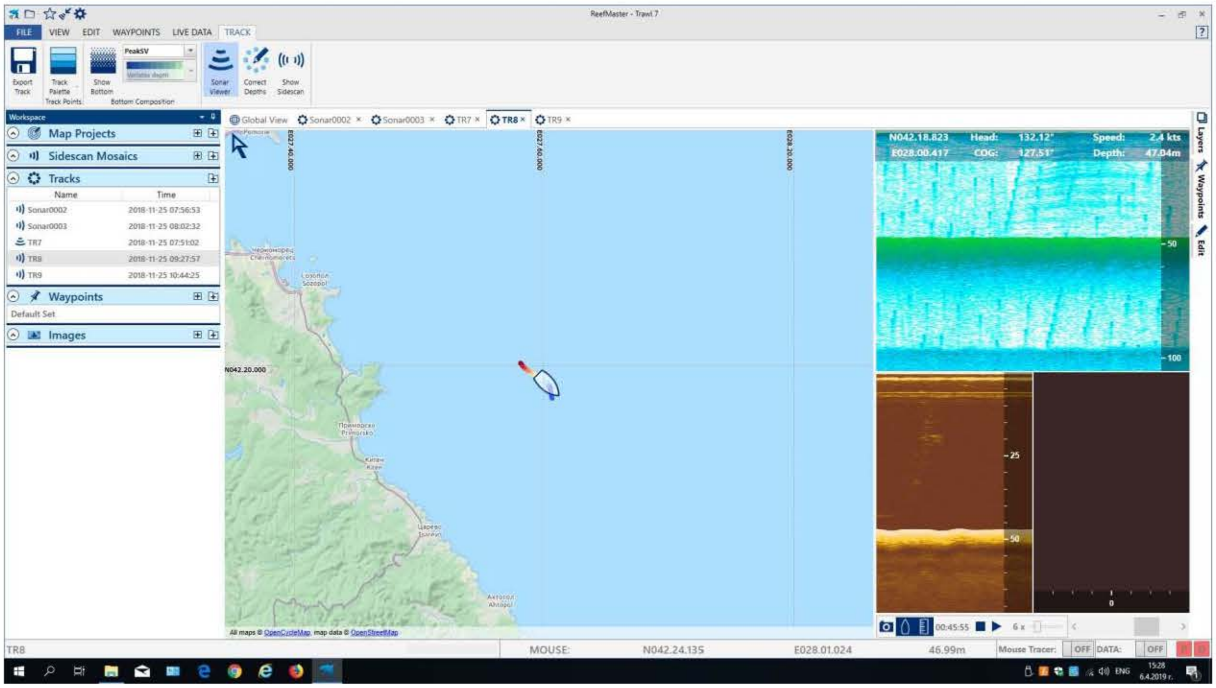


Figure X. Trawl 8, situation – 4, fish schools of M. barbatus, T. mediterraneus, P.saltatrix

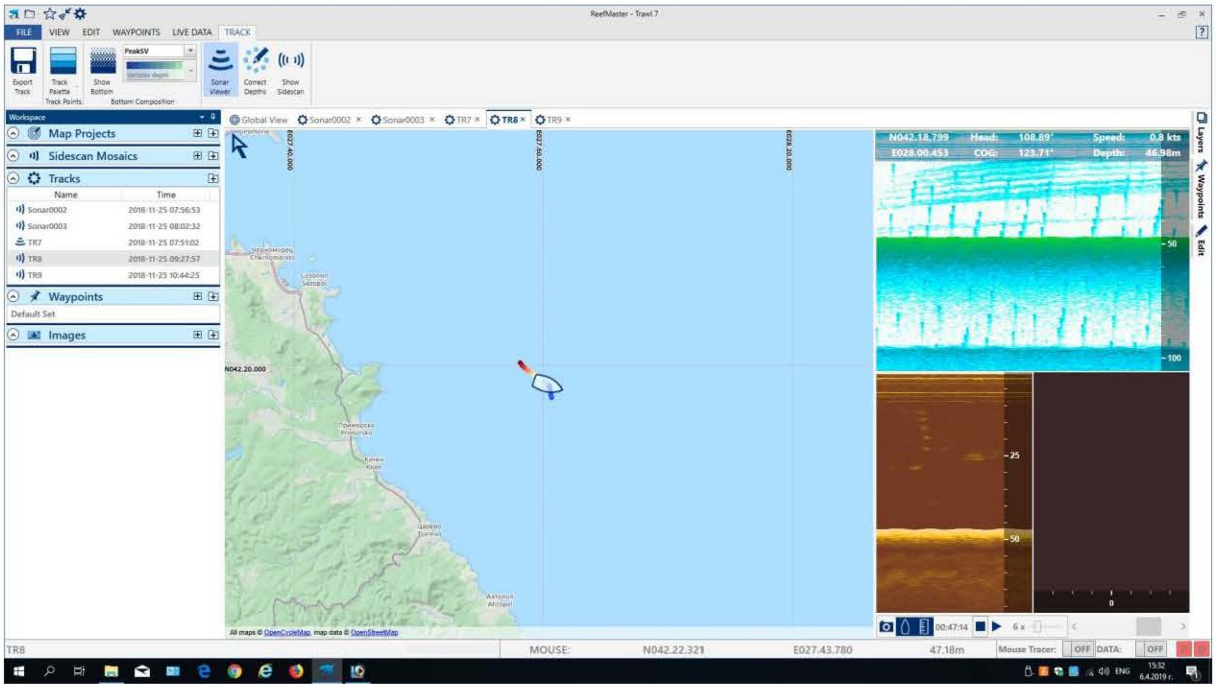
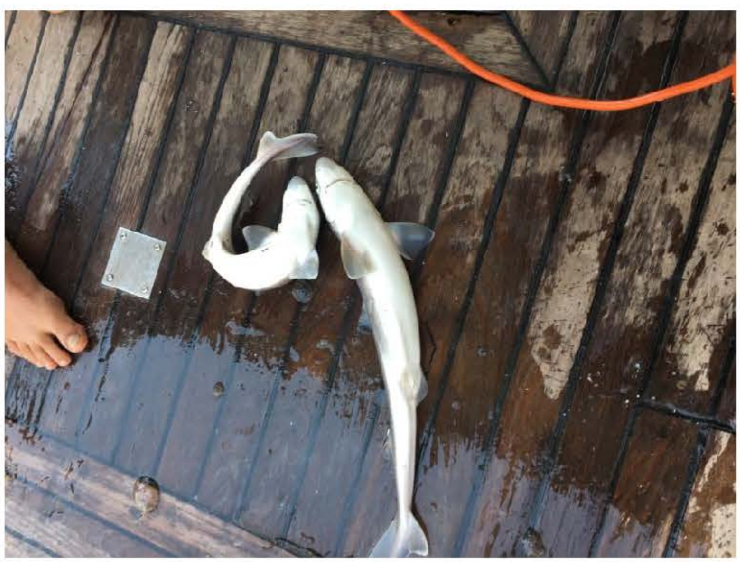


Figure XI. Trawl 8, situation – 5, end, catch - 20 kg A.aurita, 60 kg M. barbatus, 20 kg T. mediterraneus, 8 kg P.saltatrix

Pictures



Проектно предложение № BG14MFOP001-3.003-0001, „Събиране, управление и използване на данни за целите на научния анализ и изпълнението на Общата политика в областта на рибарството за периода 2017-2019 г.“, финансирано от Програмата за морско дело и рибарство, съфинансирана от Европейския съюз чрез Европейския фонд за морско дело и рибарство.